AQA (GCSE Notes)

Chapter 5: Forces

Q1. State what a scalar quantity is and give one example.
Answer: A scalar quantity is a quantity that has only magnitude (size) and no direction. An example of a scalar quantity is temperature.

Q2. Describe how a vector quantity differs from a scalar quantity.
Answer: A vector quantity has both magnitude and direction, whereas a scalar quantity has only magnitude. This means that vectors show not just how much but also which way, while scalars only tell how much.

Q3. Explain how the length of an arrow can show the magnitude of a vector.
Answer: In diagrams, vectors are drawn as arrows. The length of the arrow represents the size or magnitude of the vector. A longer arrow means a larger force or quantity, while a shorter arrow means a smaller one.

Q4. Describe how the direction of an arrow represents the direction of a vector.
Answer: The direction in which the arrow points shows the direction of the vector quantity. For example, if a force acts to the right, the arrow will point to the right.

Q5. Give two examples of vector quantities found in mechanics.
Answer: Two examples of vector quantities in mechanics are force and velocity. Both have size and act in a particular direction.

Q6. Give two examples of scalar quantities found in mechanics.
Answer: Two scalar quantities in mechanics are speed and mass. They do not involve direction, only magnitude.

Q7. Define a force in simple terms suitable for GCSE study.
Answer: A force is a push or a pull that acts on an object. It can make things move, stop, speed up, slow down or change direction.

Q8. Explain why force is classed as a vector quantity.
Answer: Force is a vector because it has both a size (how strong it is) and a direction (where it's applied). For example, a 10 N force to the right is different from a 10 N force to the left.

Q9. Distinguish between contact and non-contact forces with one example of each.
Answer: Contact forces occur when two objects are physically touching, like friction between shoes and the ground. Non-contact forces act over a distance without touching, like gravity pulling objects towards Earth.

Q10. State what is meant by a contact force and name one situation where it acts.
Answer: A contact force is a force that happens when two objects are physically in contact. For example, when you push a shopping trolley, your hands apply a contact force on it.

Q11. State what is meant by a non-contact force and name one situation where it acts.
Answer: A non-contact force acts on an object without physical contact. Gravity is a non-contact force that pulls a falling apple towards the ground.

Q12. Name the force that opposes motion between two surfaces in contact.
Answer: The force that opposes motion between two touching surfaces is called friction.

Q13. Describe how air resistance acts on a falling object.
Answer: Air resistance pushes against a falling object in the opposite direction to its motion. As the object speeds up, air resistance increases until it balances the weight, causing the object to fall at a constant speed.

Q14. Explain the role of tension in a stretched cable supporting a load.
Answer: Tension is the force in a stretched cable that pulls equally at both ends. It balances the weight of the load, stopping it from falling, and keeps the cable tight.

Q15. Define normal contact force and name a common example.
Answer: A normal contact force is the force that acts at 90 degrees (right angle) to a surface when an object rests on it. For example, a book lying on a table experiences an upward normal contact force from the table.

Q16. State the non-contact force that keeps planets in orbit around the Sun.
Answer: Gravity is the non-contact force that keeps planets in orbit around the Sun.

Q17. Give one everyday example of electrostatic force acting between objects.
Answer: A common example is when you rub a balloon on your hair, and it sticks to a wall. The electrostatic force pulls the balloon to the wall without touching.

Q18. Describe a situation where magnetic force acts without the objects touching.
Answer: When you bring a magnet close to a fridge door, it pulls toward it even before touching. This is magnetic force acting at a distance.

Q19. Explain, using arrows, how to show two equal forces acting in opposite directions on an object.
Answer: Two arrows of the same length are drawn in opposite directions from the object. The equal length shows equal magnitude, and opposite directions show the forces are balanced.

Q20. A box rests on a table. Describe the pair of forces acting between the box and the table.
Answer: The box exerts a downward force (its weight) on the table due to gravity. The table pushes back with an equal upward normal contact force. These two forces are balanced.

Q21. A skydiver reaches terminal velocity. Explain why the forces on the skydiver are balanced at this point.

Answer: At terminal velocity, air resistance equals the weight of the skydiver. Since both forces are equal and opposite, they balance out, and there is no net force. The skydiver falls at constant speed.

Q22. Draw and label a force diagram for a car being towed at constant speed along a straight road.

Answer: The diagram should show four forces: forward force from the tow rope, backward force of friction, downward force of weight, and upward normal contact force from the road. The forward and backward forces are equal, as are the vertical ones.

Q23. Explain why friction is needed for a person to walk forward.

Answer: When you push your foot backward against the ground, friction pushes forward on your foot. This forward friction force is what lets you move forward. Without friction, you would slip.

Q24. Describe what happens to the net force on an object when two equal but opposite forces act on it.

Answer: When equal and opposite forces act on an object, they cancel each other out. This means the net force is zero, and the object either stays still or continues moving at a constant speed.

Q25. A book slides to a stop on a rough surface. Identify the force that causes it to stop and explain its effect.

Answer: The force is friction. As the book moves, friction acts in the opposite direction to slow it down. Eventually, friction removes all its kinetic energy, and the book comes to a stop.

Q26. Explain how you would represent a force of 5 N acting to the right using a scale diagram.

Answer: To represent a 5 N force to the right, choose a scale like 1 cm = 1 N. Then draw a straight arrow 5 cm long pointing to the right. Label the arrow with "5 N". This arrow shows both the magnitude (5 N) and the direction (to the right) of the force clearly using the scale.

Q27. Describe the forces acting between two magnets facing like poles toward each other.

Answer: When like poles of two magnets are facing each other (e.g., north-north or south-south), they repel. Each magnet experiences a force pushing it away from the other. These forces are equal in size and opposite in direction, following Newton's third law.

Q28. Explain the interaction between a charged balloon and a neutral wall.

Answer: A charged balloon induces a charge in the wall's surface by attracting opposite charges and repelling like charges. This causes the balloon to stick to the wall even though the wall is neutral overall. The attraction between opposite charges at the surface causes the balloon to stay attached.

Q29. State Newton's third law and apply it to a swimmer pushing water backwards.

Answer: Newton's third law states that every action has an equal and opposite reaction. When a swimmer pushes water backward with their hands, the water pushes forward on the swimmer with an equal force. This forward reaction propels the swimmer through the water.

Q30. Describe how gravitational force varies with distance between two masses.
Answer: Gravitational force decreases as the distance between two masses increases. Specifically, it follows an inverse square law: if the distance doubles, the gravitational force becomes one-fourth as strong. So, the farther apart the objects are, the weaker the gravitational pull between them.

Q31. Explain why astronauts experience weightlessness while orbiting Earth.
Answer: Astronauts in orbit are in free fall towards Earth due to gravity, but they also move forward fast enough to keep missing it. Since they and their spacecraft fall at the same rate, there is no normal contact force acting upward on them, so they feel weightless even though gravity is still acting.

Q32. Give one example of a situation where tension and weight act in opposite directions.
Answer: A lamp hanging from the ceiling by a wire is an example. The weight of the lamp pulls downward due to gravity, while the tension in the wire pulls upward. If the lamp is at rest, these two forces are balanced and act in opposite directions.

Q33. A cyclist moves through still air. Describe the main forces acting on the cyclist and how they affect motion.
Answer: The main forces on the cyclist are forward force from pedaling, backward air resistance, and friction from the road. Gravity pulls the cyclist down, and the road pushes up with a normal contact force. If the pedaling force is greater than air resistance and friction, the cyclist speeds up; if equal, the speed stays constant.

Q34. Explain why normal contact force on an inclined plane is less than the weight of the object.
Answer: On an inclined plane, only part of the object's weight acts perpendicular to the surface. The normal contact force balances this perpendicular component, not the full weight. The rest of the weight pulls the object down the slope, causing it to slide or accelerate.

Q35. Describe how the electrostatic force between two charged objects changes when the distance between them doubles.
Answer: Electrostatic force follows an inverse square law, so when the distance doubles, the force becomes one-fourth as strong. This means increasing the gap between two charged objects weakens the attraction or repulsion between them significantly.

Q36. Explain why magnetic force is considered a non-contact force.
Answer: Magnetic force is a non-contact force because it acts at a distance without the objects needing to touch. For example, a magnet can pull a paperclip toward it even when there's air or space between them.

Q37. A rope in tug-of-war experiences two 300 N pulls in opposite directions. State the magnitude and direction of the net force on the rope.
Answer: If both teams pull with 300 N in opposite directions, the net force is 0 N. This means the rope does not accelerate and stays in the same position unless one side pulls harder.

Q38. Describe the force interaction between Earth and an apple that has just left a tree branch.
Answer: When the apple falls, Earth pulls it downward with gravitational force. According to Newton's third law, the apple pulls upward on Earth with an equal force. However, Earth's huge mass means its motion is not noticeable, while the apple accelerates downward.

Q39. Explain how a parachute increases air resistance and the effect on the skydiver's motion.
Answer: A parachute increases surface area, which increases air resistance. This greater air resistance opposes the skydiver's motion and reduces speed quickly. Eventually, air resistance balances weight, and the skydiver reaches a slower terminal velocity for a safe landing.

Q40. A box is pushed across a smooth surface with no friction. Explain what happens to its motion when the pushing force stops.
Answer: With no friction and the pushing force removed, there's no net force acting on the box. According to Newton's first law, the box continues to move in the same direction at constant speed.

Q41. Describe how you would use vector addition to find the resultant of two forces at right angles.
Answer: To find the resultant of two perpendicular forces, draw them as arrows forming a right-angled triangle. Use the Pythagorean theorem to calculate the resultant:
Resultant force = $\sqrt{(\text{force}_1^2 + \text{force}_2^2)}$.
The angle of the resultant can also be found using trigonometry.

Q42. Explain why the term "upthrust" is used instead of "buoyant force" in GCSE Physics.
Answer: "Upthrust" is a simpler term that clearly describes the upward force acting on an object in a fluid. It helps students understand that it's the force pushing up against gravity, making it easier to grasp than the more technical term "buoyant force."

Q43. Two students pull a sled with forces of 50 N and 30 N at the same angle to the direction of travel. Describe how to find the resultant force.
Answer: Since both forces act in the same direction, the resultant force is simply the sum: 50 N + 30 N = 80 N. The sled moves in that direction with an overall force of 80 N.

Q44. Explain how the normal contact force adjusts when additional mass is added to a stationary elevator floor.
Answer: When mass is added, the weight increases, so the normal contact force also increases to balance the extra downward force. This keeps the object stationary, maintaining the balance of vertical forces.

Q45. Describe an experiment to measure frictional force between a wooden block and a surface.
Answer: Place a wooden block on a flat surface and attach a spring balance to it. Pull the block steadily and note the reading on the spring balance just as the block begins to move. This reading shows the frictional force. Repeat on different surfaces to compare friction.

Q46. Explain why gravitational force is always attractive, not repulsive.
Answer: Gravity always pulls objects toward each other because it depends on mass, and mass is always positive. There's no opposite mass to cause repulsion, so gravity always attracts.

Q47. A magnet is brought near a steel paperclip. Describe the forces acting on both objects during attraction.
Answer: The magnet pulls the paperclip toward it using magnetic force. At the same time, the paperclip pulls on the magnet with an equal force in the opposite direction. This interaction follows Newton's third law.

Q48. Explain why air resistance increases with speed for a cyclist.
Answer: As a cyclist goes faster, more air is pushed out of the way per second. This increases collisions with air molecules, making air resistance grow. So, the faster you go, the more air pushes back.

Q49. Describe how tension changes along a rope when a climber hangs motionless from its end.
Answer: The tension is greatest at the top of the rope because it supports the entire weight of the climber. As you go down the rope, less of the climber's weight is supported, so tension decreases toward the bottom.

Q50. Explain how action-reaction force pairs allow a rocket to accelerate in space where no air is present.
Answer: When the rocket pushes exhaust gases backward, the gases push the rocket forward with equal force. Even in space, there's nothing to stop the rocket, so this reaction force causes it to accelerate forward.

Q51. How does the weight of a 5 kg object change if the gravitational field strength doubles?
Answer: Weight is the product of mass and gravitational field strength, $W = mg$. The mass of 5 kg stays the same, but if g doubles, the product doubles, so the weight doubles too. A 5 kg mass that weighs 49 N when $g = 9.8$ N/kg would weigh 98 N when $g = 19.6$ N/kg. This direct-proportion link means any percentage rise in g produces the same percentage rise in W because mass is constant, so the factor of two multiplies straight through to the final weight.

Q52. Explain why mass stays constant when an object is moved from Earth to the Moon even though its weight changes.
Answer: Mass counts how much matter is in an object, and the amount of matter does not alter when the object's position changes. The Moon's weaker gravitational field simply pulls less strongly, so weight, which is the force of that pull, drops, but the number of atoms in the object and their total inertia remain identical. That is why a bathroom scale that measures weight will show a smaller reading on the Moon, yet a balance scale that compares masses side-by-side shows no change.

Q53. Describe the steps for using a spring-balance to measure the weight of a metal block in a school laboratory.

Answer: First check the spring-balance is calibrated by confirming the pointer sits at zero with no load; adjust the zero screw if needed. Hang the balance vertically so the spring is free. Hook the metal block securely to the bottom loop. Let the block hang without touching anything so only gravity stretches the spring. Wait for the pointer to settle, then read the scale at eye level to avoid parallax. Record the reading in newtons, repeat twice more, and take an average to reduce random errors.

Q54. A student plots a graph of weight against mass for several objects. Explain why the graph should be a straight line through the origin.

Answer: The equation W = mg shows weight is directly proportional to mass with g as the constant gradient. Direct proportion means doubling mass doubles weight, halving mass halves weight, and so on, creating a constant ratio W/m. Graphically, that constant ratio appears as a straight line. Because a mass of zero must have zero weight, there is no offset, so the line passes through the origin. The slope of the line equals the local gravitational field strength.

Q55. State the SI units for weight, mass, and gravitational field strength.

Answer: In the International System of Units, weight is measured in newtons (N) because it is a force. Mass is measured in kilograms (kg) because it represents the quantity of matter. Gravitational field strength is measured in newtons per kilogram (N/kg) because it tells how much force acts on each kilogram of mass. Using these linked units keeps the equation W = mg consistent and lets scientists compare measurements anywhere without conversion confusion.

Q56. A 12 kg suitcase weighs 108 N on Earth. Calculate the gravitational field strength used in this calculation.

Answer: Solution:

Formula: $g = W / m$

Values: $W = 108$ N, $m = 12$ kg

$g = 108 \text{ N} / 12 \text{ kg}$

$g = 9$ N/kg

Answer: The calculation uses a gravitational field strength of 9 N/kg, slightly lower than the standard 9.8 N/kg. This rounded classroom value is often chosen for simple arithmetic and still illustrates that dividing weight by mass yields the local g. It also shows that small changes in the assumed g directly change the computed weight, reflecting the direct proportionality between these two quantities.

Q57. Give a practical reason why it is useful to know the centre of mass when designing a bridge beam.

Answer: Knowing the centre of mass lets engineers predict how the beam will tilt or rotate when lifted, transported, or placed. By fastening lifting hooks exactly above this point, the beam hangs level and avoids twisting that could crack welds or overstress sections. It also helps position supports so the load is shared evenly, reducing bending moments and preventing sagging. Accurate centre-of-mass data therefore improves safety during construction and prolongs the bridge's working life.

Q58. Describe how you could find the centre of mass of an irregular card shape in the classroom.

Answer: Suspend the card from a pin pushed through one edge and allow it to hang still; draw a vertical line straight down from the pin using a plumb-line. Rotate the card, hang it from a different edge, and draw another plumb-line. Where the two lines cross marks the centre of mass because the object always hangs so that its weight acts below the pivot. Repeating from a third point improves accuracy. Cutouts or holes don't affect the method; the crossing point still shows the balance point.

Q59. A spacecraft far from any planet has a gravitational field strength close to zero. Explain what happens to the weight of a tool inside the craft.

Answer: Weight equals mass times g, so when g is nearly zero, the weight becomes negligible. The tool still possesses mass and inertia, meaning it resists acceleration, but the force pulling it toward the craft's floor is essentially absent. Therefore it floats relative to the cabin until another force, such as a push from an astronaut or contact with a wall, changes its motion. This "microgravity" environment creates the sensation of weightlessness even though gravity is not entirely gone.

Q60. Explain why an astronaut's mass reading on a balance scale must be taken differently in orbit compared with on Earth.

Answer: A normal bathroom scale works by measuring the upward normal force needed to support the astronaut's weight. In orbit that weight is essentially zero, so the scale provides no reading. Instead, astronauts use an inertial balance: they sit on a seat connected to springs and oscillate back and forth. The period of the oscillation depends on mass. By timing the motion and comparing it to calibration curves obtained on Earth, their mass can be determined without relying on weight.

Q61. A physics book shows the symbol $W \propto m$. Explain what this symbol statement means in words.

Answer: The symbol "$\propto$" means "is directly proportional to." So $W \propto m$ reads as "weight is directly proportional to mass." In other words, if you double the mass of an object, its weight doubles; if you halve the mass, the weight halves, provided the gravitational field strength stays the same. This proportionality is the reason that a graph of weight versus mass is a straight line and why a single constant, g, links the two.

Q62. Describe two factors that could cause experimental error when using a spring-balance to measure weight.

Answer: First, parallax error arises if the observer's eye is not level with the pointer, causing the reading to appear higher or lower. Second, zero error occurs when the spring-balance does not return exactly to zero before measuring; any offset adds or subtracts from all subsequent readings. Additional errors include stretching the spring beyond its elastic limit, temperature changes altering spring stiffness, or the object moving during reading, each leading to inaccurate force values.

Q63. A rock has a mass of 3 kg. Calculate its weight on a planet where g = 15 N/kg.

Solution:

Formula: $W = m\,g$

Values: $m = 3$ kg, $g = 15$ N/kg

$W = 3 \text{ kg} \times 15 \text{ N/kg}$

$W = 45 \text{ N}$

Answer: The rock weighs 45 N on that planet. The higher gravitational field strength compared with Earth means the same mass experiences a stronger downward pull, so its weight rises in direct proportion to g, again illustrating $W \propto g$ for constant mass.

Q64. Explain why the reading on a calibrated spring-balance increases when additional masses are hung on it.
Answer: Each added mass increases the gravitational force acting downward, stretching the spring further. Hooke's law states that extension is directly proportional to the applied force within the elastic limit. The calibrated scale converts the measured extension into a force reading in newtons. Because the spring's stiffness is fixed, greater extension corresponds to greater force, so the pointer moves to larger values as more mass is added.

Q65. Discuss why weight is considered a vector while mass is not.
Answer: Weight is a force and all forces have both magnitude and direction: they act toward the centre of the attracting body. On Earth that direction is "down." Mass, however, is a scalar that measures how much matter an object contains and how strongly it resists acceleration. It has no associated direction; an object's 2 kg of matter exists the same way in every orientation. This difference is why arrows represent weight in diagrams but only numbers represent mass.

Q66. A technician adjusts the zero of a spring-balance before use. State why this step is important.
Answer: Zeroing removes any preload or mechanical drift in the spring so that the scale starts at 0 N with no load. If not corrected, every reading would carry a systematic error equal to the offset, making the data consistently too high or too low. Accurate zeroing ensures that subsequent measurements reflect only the actual force applied by the objects being weighed, improving reliability and making the instrument's calibration valid.

Q67. A bag of apples weighs 18 N on Earth. Predict its weight on Mars where g ≈ 3.7 N/kg.
Solution:
First find mass: $m = W / g_{Earth}$
$m = 18\ \text{N} / 9.8\ \text{N/kg}$
$m \approx 1.84\ \text{kg}$
Now use Martian g: $W_{Mars} = m\, g_{Mars}$
$W_{Mars} \approx 1.84\ \text{kg} \times 3.7\ \text{N/kg}$
$W_{Mars} \approx 6.8\ \text{N}$
Answer: The apples would weigh about 6.8 N on Mars, roughly one-third their Earth weight. This example demonstrates how a weaker gravitational field produces a proportionally smaller weight while mass stays the same.

Q68. Give one reason why knowing the centre of mass helps improve the stability of a tall structure.
Answer: Stability is enhanced when the line of action of weight passes within the base area. If engineers design the structure so its centre of mass remains low and well inside its footprint, wind or minor tilts are less likely to shift the weight line beyond the edge, which would cause topple. By

locating heavy components nearer the ground or widening the base to encompass the centre of mass, designers make the building safer against overturning forces.

Q69. Describe how gravitational field strength varies with altitude above Earth's surface.
Answer: Gravitational field strength decreases with increasing altitude because g is inversely proportional to the square of the distance from Earth's centre. Near the surface the change is small—about 0.3 N/kg drop per 10 km—but at orbital heights of several hundred kilometres, g falls to roughly 90 % of the surface value. Even farther out, at geostationary orbit, g is only about 0.23 N/kg. Despite the drop, gravity never reaches zero; it just weakens with distance.

Q70. Explain why the proportionality between weight and mass makes it possible to use mass scales calibrated in newtons.
Answer: Because W = mg, a mass scale can convert between kilograms and newtons simply by multiplying by the constant local g. Manufacturers exploit this by printing dual markings: kilograms on one side, newtons on the other. As long as the scale is used where g matches its calibration, each kilogram marking corresponds to a fixed newton value. The direct proportion ensures that weighing an object gives its mass and, instantaneously, its weight.

Q71. A graph of weight against gravitational field strength for a fixed mass is plotted. Describe the expected shape.
Answer: With mass held constant, the equation rearranges to W = m g, meaning weight varies linearly with g. The graph is a straight line through the origin because zero field strength gives zero weight. The line's gradient equals the mass. Thus increasing g produces proportional increases in W, and any doubling of g yields a doubling of W without curvature or deviation, provided the mass truly stays constant.

Q72. Outline a method to verify experimentally that weight is proportional to mass.
Answer: Collect a set of slotted masses from 0.5 kg to 5 kg. Use a calibrated spring-balance to measure the weight of each in newtons. Record pairs of mass and weight values. Plot weight on the y-axis and mass on the x-axis. Draw the best-fit line. If the points form a straight line through the origin with minimal scatter, the experiment confirms proportionality. The slope of the line should match the accepted local gravitational field strength within experimental error.

Q73. A diver underwater experiences the same mass but feels less weight. Explain this observation.
Answer: While the diver's mass and the gravitational pull on that mass remain unchanged, the water exerts an upward buoyant force equal to the weight of the displaced water. This upthrust partially balances the downward weight, leaving a smaller net force that the diver perceives as reduced weight. In very deep water or with a wetsuit adding volume, the upthrust may nearly equal weight, creating near-neutral buoyancy that lets the diver float effortlessly.

Q74. Calculate the mass of an object that weighs 44 N on a planet where g = 11 N/kg.
Solution:
Formula: m = W / g

Values: W = 44 N, g = 11 N/kg
m = 44 N / 11 N/kg
m = 4 kg
Answer: The object's mass is 4 kg. Dividing the measured weight by the planet's gravitational field strength isolates mass, which does not change with location. This constant mass would weigh differently on planets with other g values, but it would still be 4 kg of matter everywhere.

Q75. Explain how the concept of centre of mass is applied when designing sports equipment like javelins.
Answer: Engineers place the centre of mass slightly forward of the javelin's geometric centre. During flight, air resistance acts mostly on the middle, while gravity acts at the centre of mass. With the mass ahead, the nose stays downwind, keeping the javelin stable and aligning its tip for a safe, legal landing angle. Balancing weight distribution this way enhances aerodynamic performance, maximises distance, and complies with sporting regulations that demand predictable, controlled trajectories.

Q76. A crate weighs 500 N on Earth. Determine its mass. Assume g = 9.8 N/kg.
Solution:
Formula: m = W / g
Values: W = 500 N, g = 9.8 N/kg
m = 500 N / 9.8 N/kg
m ≈ 51 kg
Answer: The crate's mass is about 51 kg. The division separates the force of gravity from the matter present, showing that on Earth roughly fifty-one kilograms of material are needed to give a weight of five hundred newtons. This method works anywhere: divide the local weight by the local g to reveal the constant mass that does not change with location.

Q77. Explain why the weight of an object is lower at the equator than at the poles.
Answer: Two effects combine to reduce weight at the equator. First, Earth is not a perfect sphere; its surface is about 21 km farther from the centre at the equator than at the poles, so the inverse-square law makes g slightly weaker. Second, Earth's rotation provides an outward (centrifugal) effect that partly counteracts gravity; at the poles there is no such outward effect, but at the equator it subtracts roughly 0.034 N/kg from g. Together these factors lower the gravitational pull and therefore the measured weight of any object.

Q78. A science class uses different spring-balances with varied calibrations. Discuss how calibration affects accuracy.
Answer: Calibration fixes the relationship between spring extension and force reading. If the scale is marked with the wrong spacing or if the spring has aged and lost stiffness, the displayed force will be systematically high or low across the full range. Accurate calibration uses standard weights to set the zero point and scale divisions. Poorly calibrated balances give results that do not agree with accepted values, leading to incorrect calculations of mass or g and masking real proportional trends. Regular recalibration keeps measurements trustworthy and comparable.

Q79. Describe how you would modify a simple balance to measure weight instead of mass.
Answer: A classic two-pan balance compares unknown mass to standard masses, canceling weight out. To make it read weight, attach a calibrated spring mechanism under one pan so gravity stretches the spring directly. Replace the fixed mass markers with a newton scale and ensure friction is low so the pointer shows the spring's tension. Calibrate with known weights so the spring displacement corresponds to force rather than mass. The altered device now converts the downward pull of gravity into a direct weight reading.

Q80. Explain the significance of the phrase "weight acts at the centre of mass" in free-body diagrams.
Answer: In diagrams we treat the distributed gravitational pull on every particle of the object as a single force arrow starting at the centre of mass. This simplifies analysis of motion and rotation. If the arrow's line of action passes through the pivot or support, the object will not topple; if it falls outside, a turning moment appears. Using a single vector at the centre of mass lets students predict equilibrium, calculate torques, and understand stability without drawing countless small forces.

Q81. A satellite in low Earth orbit experiences microgravity. Clarify why this does not mean gravity is absent.
Answer: At 400 km altitude g is still about 8.7 N/kg, only slightly less than at the surface. The satellite and everything inside it are constantly falling toward Earth but also moving forward fast enough to keep missing it. Because the craft, the crew, and any loose objects all share the same free-fall acceleration, they exert almost no normal forces on each other, creating the sensation of weightlessness. Gravity is essential to keep the satellite in orbit; it is the very reason the craft curves around the planet rather than flying straight.

Q82. Calculate the gravitational field strength on a moon where a 4 kg hammer weighs 8 N.
Solution:
Formula: $g = W / m$
Values: $W = 8$ N, $m = 4$ kg
$g = 8 \text{ N} / 4 \text{ kg}$
$g = 2$ N/kg
Answer: The moon's gravitational field strength is 2 N/kg, one-fifth of Earth's. This low value explains why astronauts on such a moon could jump high and tools feel light even though their masses remain unchanged.

Q83. Explain why mass is taken as the same value in any physics equation regardless of location.
Answer: Mass measures the amount of matter and the inertia of an object, properties that depend only on the count of particles and not on external conditions. Moving an object between planets or into deep space does not change its particle count or how strongly it resists acceleration, so equations like $F = ma$ or $p = mv$ rely on a fixed mass term. Treating mass as constant lets physicists apply universal laws without recalculating for each environment, simplifying predictions of motion anywhere in the universe.

Q84. A climber standing on a mountain summit weighs slightly less than at sea level. Give two reasons for this difference.
Answer: First, the summit is farther from Earth's centre, so gravitational field strength is weaker by the inverse-square law; an altitude of 4 km reduces g by about 0.001 N/kg. Second, the climber spins with Earth, and the radial distance from the rotation axis is slightly greater higher up, adding a marginal increase in the centrifugal effect that offsets gravity. Combined these effects shrink weight by a small but measurable amount, even though mass, and therefore inertia, are unchanged.

Q85. Describe how proportionality can be tested by comparing the weights of identical masses at different locations on Earth.
Answer: Use identical calibrated masses and measure their weights with a high-precision spring balance at the equator, mid-latitudes, and a polar research station. Record weight and local g data. Plot weight versus gravitational field strength. If weight is proportional, each mass's data points should form a straight line through the origin, with the slope equal to the mass. Consistency across locations confirms that W/m remains constant for a given g, validating the direct proportionality independent of position.

Q86. Explain how to use a conversion factor to change a weight measurement in newtons to a mass in kilograms.
Answer: The conversion factor is the local gravitational field strength g. Divide the weight value by g: m = W / g. For example, a weight of 120 N measured where g = 9.8 N/kg becomes 120 N ÷ 9.8 N/kg ≈ 12.2 kg. Because the unit N/kg cancels, the result is in kg. This simple division lets engineers and students translate force readings into masses whenever g is known, avoiding the need to carry separate mass scales to every location.

Q87. A 0.75 kg ball is taken to a planet where its weight is 6 N. Calculate the planet's gravitational field strength.
Solution:
Formula: g = W / m
Values: W = 6 N, m = 0.75 kg
g = 6 N / 0.75 kg
g = 8 N/kg
Answer: The planet's gravitational field strength is 8 N/kg, about 82 % of Earth's. Knowing this g allows scientists to predict how objects will fall and design equipment suited to the planet's weaker pull.

Q88. Discuss why astronauts train under water to experience reduced effective weight.
Answer: Water provides buoyant force that partially counters weight, simulating microgravity's reduced support forces on muscles and joints. By adjusting suit ballast, trainers make the net force close to zero so astronauts can rehearse tasks like using tools or installing equipment without the support of their own weight, closely matching orbital work conditions. The resistance of water also slows movements, providing time to practice deliberate, controlled actions needed when inertia replaces friction in space.

Q89. A suspended meter rule balances horizontally when a 1 N weight is 40 cm from the pivot. Explain how this relates to its centre of mass.

Answer: For the rule to balance, the clockwise moment from the 1 N weight must equal the anticlockwise moment of the rule's own weight acting at its centre of mass. The pivot is at the 0 cm mark, so the 1 N produces a moment of 0.4 N m. Therefore the rule's weight acts 0.4 m on the opposite side. With a uniform weight distribution, the centre of mass lies at 50 cm, but because the pivot is likely near 10 cm on the other side, the calculation places the rule's centre of mass at 50 cm, confirming it is central.

Q90. Describe the procedure for drawing a free-body diagram showing weight and support forces for a resting object.

Answer: Begin with a simple outline box representing the object. Replace it with a dot at its centre of mass. Draw a downward arrow labelled W from the dot to show weight. Draw an upward arrow starting at the point of contact with the support surface labelled normal contact force N. Make the arrows opposite and equal in length to indicate balance. If friction or tension exists add horizontal arrows. Label axes, omit decorative details, and ensure only forces acting on the object are shown, not forces it exerts on others.

Q91. A load cell sensor measures force. Explain how such a sensor could be calibrated to display weight directly.

Answer: Connect the load cell to an electronic display and place standard masses on it. Record the raw voltage or digital output at each known weight. Plot output versus weight to find a linear relationship. Program the microcontroller to multiply incoming signals by the calculated slope and subtract any offset, so the display reads newtons instead of arbitrary units. Store temperature compensation factors because strain gauges drift. After calibration, the sensor converts force signals straight into accurate weight values.

Q92. Explain why mass readings taken with beam balances remain reliable on the Moon.

Answer: A beam balance compares the weight of an unknown mass with that of standard masses on the opposite pan. Both sides experience the same lunar gravitational field strength, so g cancels in the comparison. The balance tips only when the torques differ, independent of the absolute weight values. Thus a 1 kg mass on Earth still balances a 1 kg mass on the Moon even though each weighs less; the ratio of weights is unchanged, preserving accurate mass measurement.

Q93. A parcel has a mass of 2.5 kg. If it is weighed on Jupiter where g ≈ 24.8 N/kg, calculate its weight.

Solution:

Formula: $W = m g$

Values: $m = 2.5$ kg, $g = 24.8$ N/kg

$W = 2.5 \text{ kg} \times 24.8 \text{ N/kg}$

$W = 62$ N

Answer: The parcel weighs 62 N on Jupiter, more than twice its Earth weight. Heavy gravitational pull would require stronger equipment to handle even modest masses safely during exploration missions.

Q94. Discuss the effect of temperature on the calibration of a metal spring-balance and its weight readings.

Answer: As temperature rises, metal coils expand and Young's modulus falls, making the spring less stiff. For a given load the extension increases, so the scale reads higher than the true force. Conversely, cold stiffens the spring and readings drop. Unless the balance includes thermal compensation, calibration at room temperature cannot guarantee accuracy outdoors or in unheated labs. Regular checks with standard weights after temperature changes maintain reliable force measurements.

Q95. Explain how proportional reasoning helps predict weight changes when mass is scaled up in model testing.

Answer: If a small prototype has known mass and weight, scaling it up by a factor k in all dimensions multiplies volume, and therefore mass, by k^3. Since weight is proportional to mass, expected weight scales by the same k^3. Engineers use this relationship to project forces on full-size structures from small models, ensuring that bridges, aircraft wings, or ship hulls will withstand real gravitational loads without expensive full-scale trials.

Q96. A builder lifts a 200 N brick. Explain why the brick's mass is unchanged during lifting even though the applied force varies.

Answer: The builder must apply a force slightly greater than the 200 N weight to accelerate the brick upward, then reduce the force to hold it steady, yet the number of atoms in the brick remains constant. Mass measures this quantity and inertia, not the support force at any moment. Forces alter acceleration but cannot create or destroy matter, so mass stays at 200 N / 9.8 N/kg ≈ 20 kg throughout the lift.

Q97. State how the value of g is provided in examination questions and why students must use it consistently.

Answer: Exam papers usually state g either in the data sheet or within the question, commonly 9.8 N/kg or 10 N/kg for easier arithmetic. Students must use that exact value in all related calculations; mixing two values leads to inconsistent results and lost marks. Adhering to the specified g ensures answers align with the mark scheme and demonstrates disciplined use of given data.

Q98. Describe why centre-of-mass calculations are important in vehicle design for safe cornering.

Answer: During a turn the line of action of weight shifts relative to the tyre contact patch. If the centre of mass is high or too far to one side, centrifugal effects can roll the vehicle. Designers keep the centre low and central to maintain stability, allowing higher cornering speeds without tipping. Calculations also guide suspension tuning and cargo placement so the force distribution remains within safe limits even when the vehicle is fully loaded.

Q99. Explain how the weight-mass relationship aids astronauts in converting Earth-based training data to lunar conditions.

Answer: Training logs record the mass of equipment and astronauts know that on the Moon each kilogram weighs roughly one-sixth as much. By applying $W = mg$ with lunar g, they predict the forces they will feel, choose tool designs suited to reduced weight, and plan movements requiring less muscular effort. Yet they remember that mass and inertia are unchanged, so they still need the same force to start or stop motion quickly, preventing over-exertion or unintended spins.

Q100. A laboratory experiment finds that doubling the extension of a spring doubles the load it supports. Relate this observation to measuring weight with a spring-balance.
Answer: The observation confirms Hooke's law: $F \propto x$. A spring-balance relies on this linear link to translate extension into force. If doubling extension doubles load, the calibration curve is a straight line through zero, making the scale reliable across its range. Knowing the proportional constant allows students to convert any measured extension into weight, and the linearity ensures accuracy without complex corrections so long as the spring remains within its elastic limit.

Q101. Describe what is meant by the term "resultant force" and give an example involving two forces in a straight line.
Answer: The resultant force is the single overall force that has the same effect on an object as all the individual forces acting together. For example, if two forces of 10 N and 4 N act in opposite directions along a straight line, the resultant force is 6 N in the direction of the larger force. The object will move in that direction because the forces are unbalanced.

Q102. A box is pushed with 8 N to the right and pulled with 5 N to the left. Calculate the resultant force and state its direction.
Answer: The resultant force is 3 N to the right. This is found by subtracting the smaller force from the larger one (8 N - 5 N = 3 N) and taking the direction of the bigger force. The object will accelerate to the right due to this unbalanced force.

Q103. Explain what happens to an object when the resultant force acting on it is zero.
Answer: When the resultant force on an object is zero, the object will either remain stationary if it was already at rest, or it will continue to move at a constant speed in a straight line if it was already moving. This is an example of Newton's first law of motion, which states that an object will remain in its state of motion unless acted on by a resultant force.

Q104. Draw a labelled free body diagram for a book resting on a table, showing all the forces acting.
Answer: In a free body diagram of a book resting on a table, there are two forces acting. The weight of the book acts vertically downwards from its centre of mass and is labelled "Weight" or "W". The normal contact force from the table acts vertically upwards and is labelled "Normal force" or "N". These two forces are equal in size and opposite in direction, resulting in a balanced situation with no movement.

Q105. A car is acted on by a driving force of 2000 N and a resistive force of 500 N. Calculate the resultant force on the car.
Answer: The resultant force is 1500 N in the direction of the driving force. This is calculated by subtracting the resistive force from the driving force (2000 N - 500 N = 1500 N). The car will accelerate forward due to this unbalanced force.

Q106. Explain how you can resolve a diagonal force into two components at right angles using a scale diagram.
Answer: To resolve a diagonal force, draw it to scale as the hypotenuse of a right-angled triangle. From the tail of the force arrow, draw a horizontal line and then a vertical line to meet the tip of the original arrow. Measure the lengths of the horizontal and vertical components using the same scale and convert them back into force units. These components show the force's effect in the horizontal and vertical directions.

Q107. A 10 N force acts at an angle. Describe how you would use a scale diagram to find the horizontal and vertical components.
Answer: First, draw the 10 N force as an arrow at the given angle using an appropriate scale. Then, from the base of the arrow, draw a horizontal line. From the tip of the arrow, draw a line straight down to meet the horizontal line at a right angle. You now have a right-angled triangle. Measure the lengths of the horizontal and vertical lines, convert them into force values using the scale, and label them as the horizontal and vertical components.

Q108. Describe how a resultant force can be used to predict the motion of an isolated object.
Answer: The size and direction of the resultant force determine how an isolated object will move. If the resultant force is zero, the object remains at rest or keeps moving at constant speed. If there is a non-zero resultant force, the object will accelerate in the direction of that force. The larger the resultant force, the greater the acceleration, assuming the mass remains constant.

Q109. A force of 6 N acts north and a force of 8 N acts east. Explain how to determine the resultant force using a scale drawing.
Answer: Draw a horizontal line to represent the 8 N force east, then from its end draw a vertical line upwards to represent the 6 N force north. Complete the triangle by drawing a line from the starting point to the end of the vertical line. This diagonal line is the resultant force. Measure its length using the same scale and convert it into newtons. Use a protractor to measure the angle of the resultant relative to the horizontal.

Q110. Explain the difference between balanced and unbalanced forces using a free body diagram.
Answer: In a free body diagram, balanced forces are shown as arrows of equal length but in opposite directions, resulting in no overall movement. Unbalanced forces are shown as arrows where one is longer than the other, resulting in a net force in the direction of the longer arrow. Balanced forces cause no change in motion, while unbalanced forces cause acceleration in the direction of the resultant force.

Q111. Describe the motion of an object with no resultant force acting on it.
Answer: An object with no resultant force will stay in its current state of motion. If it is at rest, it stays still. If it is moving, it continues at the same speed in the same direction. This is due to Newton's first law of motion, which explains that no change in motion occurs unless a resultant force acts.

Q112. Two people pull a rope in opposite directions with equal force. Explain what happens to the rope and why.
Answer: The rope will not move because the forces are equal in size and act in opposite directions, resulting in a resultant force of zero. This means the forces are balanced, so there is no change in the motion of the rope. It remains stationary.

Q113. Explain why a resultant force causes acceleration in the direction of the net force.
Answer: A resultant force is the unbalanced force that remains after all forces on an object are combined. According to Newton's second law, this net force causes the object to accelerate in its direction. The greater the resultant force, the greater the acceleration, provided the mass stays the same.

Q114. A force of 50 N moves an object 3 m along the floor. Calculate the work done.
Solution:
Formula: $W = F \times s$
$W = 50\,N \times 3\,m$
$W = 150\,J$
Answer: The work done is 150 joules. This means 150 joules of energy were transferred to move the object through a distance of 3 metres by a 50 N force.

Q115. Explain the energy transfer that occurs when a person lifts a box from the ground.
Answer: When a person lifts a box, work is done against gravity. Energy is transferred from the person's muscles (chemical energy) to the box as gravitational potential energy. The box gains height, so its store of gravitational potential energy increases by the amount of work done.

Q116. Describe how the work done by a force is related to the distance moved by the object in the direction of the force.
Answer: The work done increases as the distance moved increases, as long as the force remains constant and acts along the direction of movement. The more the object is moved by the force, the more energy is transferred, so greater distance equals more work done. The relationship is directly proportional.

Q117. A force of 120 N moves an object 0.5 m. Calculate the work done and state the unit.
Solution:
$W = F \times s$
$W = 120\,N \times 0.5\,m$
$W = 60\,J$
Answer: The work done is 60 joules. This means 60 J of energy was transferred to move the object 0.5 m by a 120 N force.

Q118. Convert 20 newton-metres into joules. Explain your reasoning.
Answer: 1 newton-metre is equal to 1 joule. So 20 newton-metres is equal to 20 joules. This is because both units measure energy or work done and are equivalent in value. The unit “newton-metre” simply describes force multiplied by distance.

Q119. Explain why work done against friction causes an increase in temperature.
Answer: When work is done against friction, the energy used is not all transferred into useful motion. Some of the energy is transferred to the surfaces in contact as thermal energy due to friction, which increases their temperature. This is why rubbing hands together produces heat—the work done by the muscles is turned into heat energy due to friction.

Q120. Describe a real-life example where work is done against friction and what effect this has on the object.
Answer: A cyclist pedalling uphill is doing work against friction between the tyres and the road, and air resistance. Some of the energy from pedalling is transferred into heat in the tyres and the air around them, causing a rise in temperature. The cyclist must use more energy to overcome this wasted energy, making it harder to ride.

Q121. A student pulls a sled with a force of 60 N over a distance of 10 m. Calculate the work done.
Solution:
W = F × s
W = 60 N × 10 m
W = 600 J
Answer: The student does 600 joules of work. This energy is used to move the sled through 10 metres.

Q122. Explain why no work is done when a force is applied but there is no movement.
Answer: Work is only done when a force causes displacement. If a force is applied but the object does not move, the displacement is zero. Since work = force × distance, and the distance is zero, the work done is also zero. For example, pushing against a wall does not move it, so no work is done.

Q123. A worker pushes a crate 5 m across the floor with a constant force of 100 N. Describe the energy transfers that take place.
Answer: The worker uses chemical energy from their muscles, which is transferred to the crate as kinetic energy and to the floor as thermal energy due to friction. Some of the energy is also transferred into the crate as internal energy if it warms up slightly. The total energy transferred is the work done by the worker.

Q124. Describe how to use a force-distance graph to calculate work done.
Answer: On a force-distance graph, the work done is the area under the graph. If the force is constant, the graph is a rectangle and you multiply force by distance. If the force changes, you find the area under the curve using methods like counting squares or breaking the area into shapes like triangles and rectangles.

Q125. A force acts on an object but at 90° to the direction of motion. Explain why no work is done in this case.
Answer: Work is only done when a force causes movement in the same direction as the force. If the force is at 90° to the motion, like the centripetal force in circular motion, it does not cause

displacement in its own direction. Since displacement is perpendicular to the force, no energy is transferred and therefore no work is done.

Q126. Give one example each of stretching, bending, and compressing forces acting on different objects in everyday life.
Answer: Stretching occurs when pulling an elastic band. Bending happens when pressing down on the middle of a ruler held at both ends. Compression occurs when squeezing a sponge. In each case, forces act to change the shape of the object in different ways—by increasing its length, curving it, or reducing its size, respectively.

Q127. Explain why more than one force is needed to stretch a stationary object.
Answer: A single force applied to a stationary object will cause it to move, not stretch. To change the shape without moving the whole object, at least two equal and opposite forces are needed. One force pulls in one direction while another pulls or holds in the opposite direction, allowing the object to stretch in place.

Q128. Describe how bending a ruler involves applying more than one force.
Answer: When a ruler is bent, it is usually held at both ends while a third force pushes down in the middle. The hands at each end provide upward reaction forces, while the downward force in the middle causes the bend. This combination of at least three forces is needed to change the shape by bending without causing overall movement.

Q129. Explain the difference between elastic deformation and inelastic deformation.
Answer: Elastic deformation is temporary—when the forces are removed, the object returns to its original shape. Inelastic deformation is permanent—once the object is stretched or compressed beyond a certain point, it does not return to its original shape even after the forces are removed. It is permanently changed.

Q130. What condition must be met for an object to return to its original shape after a force is removed?
Answer: The object must have only undergone elastic deformation. This means the force applied must be within the object's elastic limit or limit of proportionality. If the force exceeds this limit, the object may become inelastically deformed and will not return to its original shape.

Q131. Describe what happens to a spring when it is stretched beyond its limit of proportionality.
Answer: When a spring is stretched beyond its limit of proportionality, it no longer follows Hooke's law. The extension no longer increases linearly with force. The spring becomes permanently deformed, meaning it will not return to its original length when the force is removed. It may also weaken or break.

Q132. State the equation that links force, spring constant, and extension.
Answer: The equation is: Force = Spring constant × Extension, written as $F = k\,e$. Force is

measured in newtons (N), spring constant in newtons per metre (N/m), and extension in metres (m). This equation only applies while the spring is within its elastic limit.

Q133. A spring stretches 0.15 m under a force of 3 N. Calculate the spring constant.
Solution:
F = k e
3 N = k × 0.15 m
k = 3 N ÷ 0.15 m = 20 N/m
Answer: The spring constant is 20 N/m. This means a force of 20 N would be needed to stretch the spring by 1 m.

Q134. Explain why the spring constant is different for different springs.
Answer: The spring constant depends on the material and the design of the spring. A stiffer spring made from a stronger or thicker material has a higher spring constant and resists stretching more. A soft or thinner spring has a lower spring constant and stretches more easily under force.

Q135. Describe how you could investigate the relationship between force and extension for a spring in a lab.
Answer: Hang a spring vertically and attach a ruler beside it. Add weights step by step and measure the new length each time. Subtract the original length to find the extension. Plot a graph of force (weight) versus extension. If the graph is a straight line through the origin, the spring obeys Hooke's law within that range.

Q136. Sketch and label a force-extension graph showing both linear and non-linear behaviour.
Answer: The linear part of the graph is a straight line from the origin, showing that force is directly proportional to extension. After the limit of proportionality, the graph curves, indicating that the spring is no longer obeying Hooke's law and becomes non-linear.

Q137. What is meant by a linear relationship between force and extension?
Answer: A linear relationship means that the extension increases proportionally as the force increases. The graph of force against extension is a straight line through the origin. This means the spring is behaving elastically and obeys Hooke's law, within the limit of proportionality.

Q138. Describe what is meant by the "limit of proportionality" in a spring experiment.
Answer: The limit of proportionality is the point beyond which the extension of a spring no longer increases in direct proportion to the applied force. After this point, the spring does not follow Hooke's law, and the graph of force against extension begins to curve.

Q139. Give one reason why a spring might not return to its original length after being stretched.
Answer: The spring may have been stretched beyond its elastic limit, causing inelastic deformation. In this case, permanent changes to the spring's structure occur, and it cannot return to its original length even when the force is removed.

Q140. State the unit of the spring constant and explain what it tells you.
Answer: The unit of spring constant is newtons per metre (N/m). It tells you how much force is needed to stretch or compress the spring by 1 metre. A higher value means the spring is stiffer and harder to stretch.

Q141. A spring with a spring constant of 200 N/m is stretched by 0.02 m. Calculate the force applied.
Solution:
$F = k e$
$F = 200\ N/m \times 0.02\ m = 4\ N$
Answer: The force applied is 4 newtons.

Q142. A spring is compressed by 0.04 m and has a spring constant of 250 N/m. Calculate the force needed.
Solution:
$F = k e$
$F = 250\ N/m \times 0.04\ m = 10\ N$
Answer: A force of 10 newtons is needed to compress the spring.

Q143. Explain what happens to the energy stored in a spring when it is released.
Answer: When the spring is released, the stored elastic potential energy is converted into other forms of energy. If the spring pushes something, the energy becomes kinetic energy. Some may also become sound or thermal energy if there's friction or impact.

Q144. State the equation used to calculate elastic potential energy stored in a stretched spring.
Answer: The equation is:
Elastic potential energy = ½ × Spring constant × Extension²
Written as: $E_e = \frac{1}{2} k e^2$
E_e is in joules (J), k in N/m, and e in metres (m). This equation is only valid within the elastic limit of the spring.

Q145. A spring with a spring constant of 100 N/m is stretched by 0.1 m. Calculate the energy stored.
Solution:
$E_e = \frac{1}{2} \times k \times e^2$
$E_e = \frac{1}{2} \times 100 \times (0.1)^2 = 0.5\ J$
Answer: The energy stored in the spring is 0.5 joules.

Q146. Compare the energy stored in two springs with the same extension but different spring constants.
Answer: The spring with the higher spring constant stores more energy because the energy stored is directly proportional to the spring constant when the extension is the same. This is due to the formula $E_e = \frac{1}{2} k e^2$.

Q147. Describe how you would determine the spring constant from a force-extension graph.
Answer: Plot force on the y-axis and extension on the x-axis. The spring constant is the gradient (slope) of the straight-line section. Calculate it using the formula: gradient = change in force ÷ change in extension. This gives the spring constant in N/m.

Q148. A force-extension graph has a curved section. What does this tell you about the spring?
Answer: The curved section means the spring has exceeded its limit of proportionality. It no longer follows Hooke's law, and the extension is not directly proportional to the applied force. The spring may be approaching inelastic deformation.

Q149. What is the energy transfer involved when compressing a spring?
Answer: When a spring is compressed, work is done on the spring. This energy is transferred from the person or device compressing the spring into the spring as stored elastic potential energy. If not stretched beyond its limit, the spring can release this energy later.

Q150. Explain how compression of a spring can store energy in the form of elastic potential energy.
Answer: As a spring is compressed, the force applied causes particles in the material to move closer together. This increases the internal energy stored in the spring. This stored energy is called elastic potential energy and can be released when the spring is allowed to return to its original shape.

Q151. Describe how elastic potential energy can be used in a catapult.
Answer: In a catapult, pulling back the elastic band stores elastic potential energy. When released, this stored energy is rapidly converted into kinetic energy, launching the object forward. The greater the stretch, the more energy is stored and the faster the object moves.

Q152. A spring stretches 0.2 m when a force of 4 N is applied. Calculate the energy stored in the spring.
Solution:
$k = F / e = 4\ N \div 0.2\ m = 20\ N/m$
$E_e = \frac{1}{2} \times 20 \times (0.2)^2 = 0.4\ J$
Answer: The energy stored in the spring is 0.4 joules.

Q153. Explain why doubling the extension of a spring (within the proportional limit) quadruples the energy stored.
Answer: The energy stored in a spring is given by $E_e = \frac{1}{2} k e^2$. Since extension is squared, doubling the extension means the energy increases by $2^2 = 4$ times. So if you double the extension, the energy stored becomes four times greater, assuming the spring is still within its elastic limit.

Q154. A spring is stretched but does not return to its original shape. What type of deformation has occurred?
Answer: This is inelastic deformation. The spring has been stretched beyond its elastic limit, causing permanent structural changes. It will not return to its original shape even after the force is removed.

Q155. Give one reason why it is important to know the limit of proportionality when designing a spring-loaded device.
Answer: Knowing the limit of proportionality ensures the spring is only used within its elastic range. This prevents permanent damage and ensures the spring can reliably store and release energy without becoming inelastic or breaking. It also ensures consistent performance of the device.

Q156. Give one everyday example of a force causing an object to rotate around a pivot.
Answer: A good example is opening a door. When you push or pull the door handle, a force is applied at a distance from the hinges (pivot), which causes the door to rotate. This is a clear example of a force producing a turning effect, known as a moment.

Q157. Define the moment of a force and state its unit.
Answer: The moment of a force is the turning effect it has about a pivot. It is calculated by multiplying the force by the perpendicular distance from the pivot to the line of action of the force. The unit of moment is newton-metre (Nm).

Q158. Describe how the distance from the pivot affects the size of a moment for a fixed force.
Answer: The moment increases as the distance from the pivot increases, for the same force. This is because moment = force × distance. So applying the same force further from the pivot makes it easier to cause rotation.

Q159. Explain why a door handle is placed far from its hinges.
Answer: A door handle is placed far from the hinges to increase the distance from the pivot. This increases the moment for the same force applied, making it easier to open the door with less effort.

Q160. A spanner applies a 15 N force at 0.2 m from a bolt. Write the expression for its moment.
Answer: Moment = Force × Distance = 15 N × 0.2 m = 3 Nm. This is the turning effect produced by the force acting on the spanner at that distance from the bolt.

Q161. State the condition needed for an object to be in rotational equilibrium.
Answer: An object is in rotational equilibrium when the total clockwise moment equals the total anticlockwise moment about the same pivot. In this case, there is no net turning effect, and the object remains balanced.

Q162. Describe how you could find an unknown force on a balanced seesaw using moments.
Answer: Measure the known force and its distance from the pivot. Multiply them to find the known moment. Then, measure the distance of the unknown force from the pivot. Use the equation: moment = force × distance. Rearranging allows you to calculate the unknown force that balances the seesaw.

Q163. Explain what is meant by the perpendicular distance in the moment equation.
Answer: The perpendicular distance is the straight-line distance from the pivot to the line of action of the force, measured at a right angle to the force. Only this distance is used in the moment equation because it accurately represents how far the force is from the pivot in creating rotation.

Q164. Give one reason why long-handled tools make tasks easier.
Answer: Long-handled tools increase the distance from the pivot point, which increases the moment for the same force. This means you can achieve a greater turning effect with less effort.

Q165. Explain how a crowbar acts as a lever to lift a heavy object.
Answer: A crowbar uses the principle of moments. It acts as a lever with a pivot point close to the object. By applying a force far from the pivot, a small effort can produce a large turning effect, lifting the heavy object more easily.

Q166. Name the three classes of levers and give an example of each.
Answer: First-class lever: pivot between effort and load (e.g. scissors). Second-class lever: load between effort and pivot (e.g. wheelbarrow). Third-class lever: effort between pivot and load (e.g. tweezers).

Q167. Describe how gears can change the direction of rotation.
Answer: When two gears mesh, one turns clockwise and the other turns anticlockwise. This changes the direction of rotation between the two connected gears. This is useful in machinery where the direction needs to be reversed.

Q168. Explain why a small gear driving a large gear increases turning effect.
Answer: When a small gear drives a large gear, the larger gear rotates more slowly but with a greater turning effect (moment). This happens because the larger gear has a greater radius, increasing the distance from its centre, and therefore increasing the moment.

Q169. State two differences between a simple lever and a gear system.
Answer: A simple lever uses a pivot and a straight bar to increase force or distance. A gear system uses rotating wheels with teeth that transmit motion and force. Levers work with linear motion, while gears work with rotational motion.

Q170. Describe how bicycle gears help a cyclist climb a steep hill.
Answer: On a steep hill, the cyclist uses a lower gear. This allows the pedals to turn more easily with less force, even though the bike moves more slowly. It increases the mechanical advantage, making it easier to maintain motion uphill.

Q171. Explain how a screwdriver lid opener uses the principle of moments.
Answer: A lid opener increases the distance from the pivot, allowing the user to apply a smaller force to create a larger moment. This makes it easier to twist and open tightly sealed jar lids.

Q172. A child sits 2 m from the pivot on a seesaw with a weight of 300 N. Write the moment produced.
Answer: Moment = Force × Distance = 300 N × 2 m = 600 Nm. This is the turning effect of the child's weight about the pivot of the seesaw.

Q173. A plank balances on a pivot. Explain how moving a weight closer to the pivot affects balance.

Answer: Moving the weight closer to the pivot reduces its moment, because moment = force × distance. If the opposite side remains unchanged, the plank may become unbalanced as the moments are no longer equal.

Q174. Describe an experiment to verify that clockwise and anticlockwise moments are equal for a balanced metre rule.
Answer: Hang a metre rule horizontally from a pivot at its centre. Hang known weights at different distances on each side. Adjust positions until the rule balances. Then calculate the clockwise and anticlockwise moments. If they are equal, the rule is balanced and the principle is verified.

Q175. Explain why a spanner slips less when the force is applied perpendicular to the handle.
Answer: A perpendicular force gives the maximum moment because the full value of the distance from the pivot is used. If the force is at an angle, only a component of it contributes to the moment, reducing the turning effect and increasing the chance of slipping.

Q176. Define pressure in fluids and state its unit.
Answer: Pressure in a fluid is the force acting per unit area. It acts at right angles to any surface in contact with the fluid. The unit of pressure is the pascal (Pa), where 1 Pa = 1 N/m^2.

Q177. Explain why a fluid exerts pressure at right angles to any surface.
Answer: Particles in a fluid move randomly and collide with surfaces in all directions. The result is a net force that acts perpendicular (at right angles) to the surface, creating pressure. This is observed in both liquids and gases.

Q178. State the equation that links pressure, force, and area.
Answer: Pressure = Force ÷ Area, or $p = F / A$. Pressure is in pascals (Pa), force in newtons (N), and area in square metres (m^2).

Q179. Describe how changing the area of contact affects pressure for a constant force.
Answer: If the contact area increases while the force stays the same, the pressure decreases. If the contact area decreases, the pressure increases. This is because pressure is inversely proportional to area.

Q180. Explain why snowshoes stop a person sinking into soft snow.
Answer: Snowshoes increase the surface area over which the person's weight is spread. This reduces the pressure on the snow, preventing the person from sinking in by lowering the force per unit area.

Q181. A force of 500 N acts on an area of 2 m^2. Write the expression for the pressure.
Answer: Pressure = Force ÷ Area = 500 N ÷ 2 m^2 = 250 Pa. This is the pressure exerted on the surface.

Q182. Describe how hydraulic brakes use pressure in a fluid to operate.
Answer: When the brake pedal is pressed, it applies force to a small piston. This creates pressure in

the brake fluid, which is transmitted through the fluid to larger pistons at the wheels. These pistons apply force to brake pads, stopping the vehicle.

Q183. Explain why dam walls are thicker at the base than at the top.
Answer: Water pressure increases with depth. To withstand this greater pressure near the bottom, the wall must be thicker to resist the larger force and avoid breaking or collapsing.

Q184. Give one example where high pressure is useful and one where low pressure is useful.
Answer: High pressure is useful in hydraulic presses to lift heavy loads. Low pressure is useful in vacuum packing to remove air and preserve food.

Q185. Explain how a drawing pin applies a large pressure with a small force on the paper.
Answer: The sharp tip of the drawing pin has a very small area. Even a small force applied by your hand results in a high pressure at the tip, allowing it to pierce paper easily.

Q186. Describe how pressure varies with depth in a liquid.
Answer: Pressure in a liquid increases with depth. The deeper you go, the more weight of the liquid is above you, which increases the pressure acting on objects at that depth.

Q187. Explain why a balloon expands as it rises through the atmosphere.
Answer: As the balloon rises, the atmospheric pressure outside it decreases. The higher internal pressure pushes outwards more strongly, causing the balloon to expand.

Q188. State how gas pressure in a container changes when the same amount of gas is compressed into half the volume.
Answer: If temperature stays the same, compressing the gas into half the volume doubles the pressure. This is because gas particles collide more often with the walls of the container in a smaller space.

Q189. A hydraulic press multiplies an input force. Explain the role of different piston areas in this device.
Answer: A small input piston creates pressure in the fluid, which is transmitted equally. The larger output piston receives the same pressure over a bigger area, resulting in a larger output force, multiplying the input.

Q190. Describe how a dentist's chair uses hydraulics to lift a patient smoothly.
Answer: When a small force is applied to the input piston, it creates pressure in hydraulic fluid. This pressure moves a larger piston under the chair, lifting the patient smoothly with a greater force over a larger area.

Q191. Explain why sharp knives cut better than blunt knives of the same weight.
Answer: Sharp knives have a smaller contact area. For the same force, the smaller area increases the pressure, making it easier to cut through materials like vegetables or meat.

Q192. A 200 N force acts on a surface area of 0.04 m². Write the expression to find the pressure.
Answer: Pressure = Force ÷ Area = 200 N ÷ 0.04 m^2 = 5000 Pa. The pressure exerted is 5000 pascals.

Q193. Explain how tyre pressure supports the weight of a car.
Answer: The air inside the tyres exerts pressure on the inner walls, balancing the weight of the car. This pressure is evenly distributed across the contact patch with the road, supporting the vehicle without the tyres collapsing.

Q194. Describe a method to measure the pressure at the bottom of a water tank.
Answer: Attach a pressure sensor or gauge at the bottom of the tank. The sensor measures the force per unit area exerted by the water above it, giving the pressure. Make sure the tank is filled and the depth is known for accurate reading.

Q195. Explain why divers must equalise pressure as they descend underwater.
Answer: Water pressure increases with depth. If divers don't equalise the pressure inside their ears or masks, the higher external pressure can cause pain or injury. Equalising prevents damage by balancing internal and external pressures.

Q196. Give one safety reason for storing gas cylinders upright.
Answer: Storing cylinders upright keeps the pressure release valve in the gas phase, not the liquid. This prevents sudden high-pressure discharge of liquid gas, which could cause explosions or frost injuries.

Q197. Explain the effect on pressure if the force on a piston doubles but the area stays the same.
Answer: Pressure increases because pressure = force ÷ area. If the force doubles and the area is unchanged, the pressure also doubles.

Q198. A hydraulic jack applies a 25 N force on a small piston of area 0.01 m². State the pressure transmitted through the fluid.
Answer: Pressure = Force ÷ Area = 25 N ÷ 0.01 m^2 = 2500 Pa. This pressure is transmitted equally throughout the fluid.

Q199. Describe how atmospheric pressure changes with altitude and give one consequence for aircraft cabins.
Answer: Atmospheric pressure decreases with altitude because there is less air above. In aircraft, cabins must be pressurised to keep the internal pressure at a safe level for breathing and comfort.

Q200. Explain why large tankers have many small compartments instead of one big tank to reduce stress on the hull.
Answer: Dividing the liquid into smaller compartments distributes the weight more evenly and limits sloshing. This reduces pressure spikes and stress on the hull, improving stability and preventing damage.

Q201. Explain how the height of a liquid column affects the pressure at the base of the column.

Answer: The pressure at the base of a liquid column increases as the height of the column increases. This is because pressure in a liquid is calculated using the formula $p = h\rho g$, where h is the height of the liquid, ρ is the density, and g is the gravitational field strength. As height increases, more liquid presses down on the point, increasing the pressure.

Q202. A diver descends to 15 m in seawater. State the factors that determine the pressure acting on the diver at that depth.

Answer: The pressure acting on the diver depends on the depth of water, the density of seawater, and gravitational field strength. The deeper the diver goes, the more water is above, adding more weight and increasing the pressure. This pressure is calculated using the formula $p = h\rho g$, where all three variables directly affect the total pressure at depth.

Q203. Describe why the pressure at a given depth is greater in mercury than in water.

Answer: Pressure depends on the density of the liquid. Mercury has a much higher density than water. At the same depth and under the same gravitational field, the higher density of mercury means it exerts more pressure. According to $p = h\rho g$, a larger value of ρ (density) leads to a higher pressure at the same depth compared to a less dense liquid like water.

Q204. Use the idea of particle weight to explain why atmospheric pressure decreases with altitude.

Answer: As altitude increases, there are fewer air particles above a surface, so less weight is pressing down. Atmospheric pressure is caused by air particles colliding with surfaces. At higher altitudes, the air is thinner and less dense, so there are fewer collisions and less total weight of air above, leading to a drop in atmospheric pressure the higher you go.

Q205. A submarine moves from 50 m to 150 m depth. State how this change affects the pressure on its hull and why.

Answer: The pressure on the submarine's hull increases as it moves from 50 m to 150 m. This is because pressure in a liquid increases with depth. The deeper the submarine goes, the more water is above it, and the greater the weight of that water pressing down. This increased pressure is calculated using the formula $p = h\rho g$, where h is the depth.

Q206. Explain in terms of upthrust why a steel ship floats while a steel block of the same mass sinks.

Answer: A steel ship floats because its shape causes it to displace more water, producing a larger upthrust. The upthrust equals the weight of the water displaced. The steel block is compact and displaces less water, so the upthrust is smaller and cannot balance its weight, causing it to sink. The ship's wider shape ensures the upthrust matches its weight, allowing it to float.

Q207. Describe how the density of a liquid influences the upthrust on a floating object.

Answer: The upthrust on a floating object increases with the density of the liquid. A denser liquid means that a smaller volume of fluid must be displaced to produce the same upward force. This is because the weight of the displaced liquid is higher for the same volume. So, for the same submerged volume, a higher liquid density gives a greater upthrust on the object.

Q208. A balloon rises until the atmospheric pressure outside equals the pressure inside. Explain why it stops rising at this point.

Answer: As a balloon rises, the atmospheric pressure outside decreases. The pressure inside the balloon remains relatively constant until it expands. When the pressure inside matches the pressure outside, there is no longer a net force pushing it upward. The forces become balanced, and the balloon stops rising, remaining at that altitude unless other forces act on it.

Q209. State the equation linking pressure, density, gravitational field strength, and height in a liquid column.

Answer: The equation is $p = h\rho g$. This shows that pressure (p) in a liquid increases with the height (h) of the column, the density (ρ) of the liquid, and the gravitational field strength (g). Each of these factors directly affects the pressure at a point in the liquid. The equation is used to calculate pressure at any depth in fluids.

Q210. Explain why pressure measured at the bottom of a freshwater lake differs from pressure at the same depth in the sea.

Answer: The pressure at the same depth is higher in the sea than in a freshwater lake because seawater is denser than freshwater. Pressure in a liquid depends on depth, density, and gravitational field strength. Since the density of seawater is higher due to salt content, the pressure at a given depth is also higher even though the depth and gravity are the same.

Q211. Describe how a submarine crew can calculate the external pressure at depth without a depth gauge, using density data.

Answer: The crew can use the pressure formula $p = h\rho g$ to calculate the pressure. By knowing the density of the seawater and the depth they are at (from navigation systems), and using the known value for gravity, they can calculate the external pressure on the hull. This is useful for checking structural safety and adjusting systems inside the submarine.

Q212. A diver's ear experiences discomfort as they descend. Use pressure concepts to explain this effect.

Answer: As a diver goes deeper underwater, the pressure outside the body increases. If the pressure inside the diver's ear does not equalize quickly with the external pressure, it creates a pressure difference across the eardrum. This imbalance causes the eardrum to stretch inward, leading to discomfort or even pain. Equalizing pressure prevents damage and discomfort.

Q213. Explain why the upthrust on a completely submerged object is equal to the weight of the fluid displaced.

Answer: According to Archimedes' principle, the upthrust on a submerged object is equal to the weight of the fluid it displaces. When the object is fully underwater, it pushes aside a volume of fluid. The fluid exerts an upward force on the object equal to the weight of that displaced volume. This principle explains why objects float or sink based on upthrust and weight.

Q214. Describe how a hydrometer uses floating principles to measure the density of a liquid.
Answer: A hydrometer floats higher or lower in a liquid depending on the liquid's density. It displaces a volume of liquid whose weight equals the hydrometer's weight. In denser liquids, it needs to displace less volume to balance its weight, so it floats higher. In less dense liquids, it must sink more to displace enough liquid. The scale on the stem shows the density.

Q215. Explain why a sealed plastic bottle appears crushed when brought down from a mountain to sea level.
Answer: At high altitudes, the atmospheric pressure is lower. When a bottle is sealed there and then brought to sea level, it experiences a higher external pressure from the denser air at lower altitude. The air inside the bottle remains at low pressure, so the greater outside pressure pushes inward on the bottle, crushing it slightly due to the pressure imbalance.

Q216. A hydraulic dam has sensors at different depths. Explain why the readings increase with depth even though the liquid is the same.
Answer: The deeper the sensor is placed in the dam, the greater the pressure it measures. This is because pressure increases with depth in a liquid, as more water is above the sensor. Even though the liquid is the same, the pressure depends on the weight of the water above the point. The deeper the sensor, the more weight it supports, resulting in higher pressure.

Q217. Describe the changes in atmospheric pressure a passenger experiences during a rapid airplane ascent.
Answer: As the airplane ascends quickly, the atmospheric pressure around the plane decreases rapidly because the air becomes thinner at higher altitudes. Passengers may feel this pressure change in their ears or sinuses. Cabin pressure is controlled, but not kept at sea-level pressure, so a noticeable drop still occurs, especially if ascent is fast or pressure equalization is delayed.

Q218. Explain why divers use specialised gas mixtures at great depth rather than normal air.
Answer: At great depths, the pressure is high, and breathing normal air can lead to nitrogen buildup in the body, which is dangerous and causes decompression sickness. Special gas mixtures like helium-oxygen reduce nitrogen levels and prevent this problem. They also help reduce the breathing resistance and avoid toxic effects of oxygen under high pressure.

Q219. A wooden block floats with two-thirds of its volume submerged. Explain what this indicates about the density of the wood.
Answer: If two-thirds of the wooden block is submerged, it means the block's density is two-thirds that of the liquid it is floating in. This is because the upthrust must balance the weight of the block, and the upthrust is equal to the weight of the displaced liquid. The proportion submerged shows the ratio of the object's density to the fluid’s density.

Q220. Describe how trapped air under a swimmer’s wetsuit reduces effective density and increases buoyancy.
Answer: The trapped air under the wetsuit increases the volume of the swimmer without adding much weight, which lowers the swimmer’s average density. Since buoyancy depends on displacing

fluid equal to the object's weight, a lower density makes it easier for the swimmer to float. The air provides extra volume that contributes to more upthrust from the displaced water.

Q221. Explain why the pressure difference between two depths in a liquid depends only on the vertical distance, not the container shape.
Answer: Pressure in a liquid depends on the vertical depth and not on the shape or width of the container. This is because the pressure at a depth is determined by the height of the liquid column above the point, the density of the liquid, and gravity. The sides of the container do not affect the vertical weight of the liquid pressing down on a specific point.

Q222. A deep-sea probe measures pressure as 40 MPa. Explain how to estimate the depth using typical seawater density.
Answer: To estimate depth, use the pressure formula $p = h\rho g$. Rearranging gives $h = p / (\rho g)$. With pressure as 40 MPa (40,000,000 Pa), seawater density ≈ 1025 kg/m^3, and $g = 9.8$ *N/kg*, plug in values to calculate depth. This lets scientists estimate how deep the probe is based on how much pressure the seawater exerts at that point.

Q223. Describe how barometer readings help weather forecasters predict changing weather patterns.
Answer: Barometers measure atmospheric pressure. A falling pressure reading usually indicates bad weather is approaching, like storms or rain, because low-pressure systems draw in moist air. Rising pressure suggests dry, calm weather. By tracking pressure changes over time, meteorologists can make forecasts about upcoming weather conditions in a region.

Q224. Explain why mountain climbers may develop altitude sickness using the concept of reduced atmospheric pressure.
Answer: At high altitudes, atmospheric pressure is lower, meaning there is less oxygen in each breath. The body struggles to get enough oxygen, which can cause symptoms like headaches, nausea, and fatigue—this is altitude sickness. The lower pressure also reduces oxygen availability to body tissues, making physical activity more difficult and straining bodily functions.

Q225. Discuss how submarines adjust their buoyancy by changing the density of water in ballast tanks.
Answer: Submarines adjust buoyancy by filling ballast tanks with water or air. When water is added, the submarine becomes denser and sinks because its weight increases. To rise, air is pumped in to force the water out, reducing overall density and increasing buoyancy. By carefully adjusting the amount of water and air in the tanks, the submarine can move up or down in the water.

Q226. Define distance and explain why it is a scalar quantity.
Answer: Distance is the total length of the path travelled by an object, regardless of direction. It only measures how much ground an object has covered. Since distance has only magnitude and no direction, it is a scalar quantity. For example, walking 3 km east or west is still a distance of 3 km; the direction does not affect the measurement.

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Q227. Define displacement and explain why it is considered a vector quantity.
Answer: Displacement is the straight-line distance from the starting point to the ending point of an object's movement, including the direction. It is considered a vector quantity because it has both magnitude and direction. For example, moving 5 m north from the start has a displacement of 5 m north.

Q228. A runner completes a 400 m track lap and finishes at the starting point. What is their displacement and why?
Answer: The runner's displacement is 0 m because displacement is the straight-line distance from the start to the end point. Since the runner finishes at the same place they started, there is no overall change in position, even though the distance travelled is 400 m.

Q229. How is displacement different from distance when describing a journey with turns?
Answer: Distance adds up the entire path covered, even with twists and turns. Displacement only measures the shortest straight-line distance from the starting point to the end point, with direction. So, a winding journey may have a large distance but a much smaller displacement.

Q230. Give an example of a situation where the distance travelled is greater than the displacement.
Answer: If someone walks around a park in a large circle and returns to their starting point, the total distance might be 500 m, but the displacement is 0 m because they end where they started. This shows distance can be more than displacement.

Q231. Describe how you would measure the displacement of a hiker walking through a forest with twists and turns.
Answer: You would use a GPS or a map to find the straight-line distance between the starting and ending point of the hike. Displacement is the direct distance between those two points, regardless of the actual path the hiker took.

Q232. A cyclist moves 5 km north, then 5 km south. What is the total distance travelled and the displacement?
Answer: The total distance is 10 km because the cyclist travelled 5 km in each direction. The displacement is 0 km because they returned to their original starting point, so there was no overall change in position.

Q233. Why can displacement have a negative value while distance cannot?
Answer: Displacement has direction, so movement in the opposite direction can be represented with a negative value. For example, moving 3 m backward can be written as -3 m. Distance, being scalar, is always positive because it measures total movement only.

Q234. Explain what is meant by the magnitude of displacement.
Answer: The magnitude of displacement is the size or length of the displacement vector, ignoring the direction. It tells you how far the object is from its starting point, even if it moved in a specific direction or not.

Q235. A plane flies 100 km east then 100 km north. How would you determine its total displacement?
Answer: The displacement is the diagonal straight-line from the starting point to the ending point. You would use the Pythagorean theorem: $\sqrt{(100^2 + 100^2)} = \sqrt{20000}$ = about 141.4 km northeast. This shows both magnitude and direction.

Q236. What does it mean to express displacement in terms of both magnitude and direction?
Answer: It means giving both how far the object has moved from its starting point (magnitude) and in which direction it moved. For example, a displacement of 50 m east tells us the object is 50 m away in the east direction.

Q237. Why is speed described as a scalar quantity, unlike velocity?
Answer: Speed measures how fast something moves, without considering direction, so it's scalar. Velocity includes both speed and direction, like 20 m/s north, making it a vector. That's why speed is scalar and velocity is not.

Q238. Define average speed and explain how it differs from constant speed.
Answer: Average speed is total distance divided by total time taken. Constant speed means the speed stays the same throughout the journey. If an object speeds up and slows down, it doesn't have constant speed but still has an average speed over the journey.

Q239. A person walks at 1.5 m/s for 10 minutes. Calculate the distance travelled.
Answer: Distance = speed × time = 1.5 m/s × 600 s = 900 m. So, the person travels 900 metres in 10 minutes of walking at 1.5 m/s.

Q240. Explain how fitness and terrain can affect a person's walking speed.
Answer: A fitter person may walk faster because they can maintain a higher pace for longer. Similarly, flat terrain allows faster walking, while steep or rough surfaces slow someone down due to increased effort and reduced stability.

Q241. State typical values of walking, running, and cycling speeds in m/s.
Answer: A typical walking speed is about 1.5 m/s, running speed is about 3 m/s, and cycling speed is around 6 m/s. These are average values and can vary depending on fitness, conditions, and type of surface.

Q242. A train covers 600 m in 20 s. What is its average speed?
Answer: Speed = distance ÷ time = 600 m ÷ 20 s = 30 m/s. So the average speed of the train is 30 metres per second over that time.

Q243. Explain why the speed of a moving vehicle is rarely constant.
Answer: Vehicles often change speed due to traffic, road conditions, or driver actions like braking or accelerating. As a result, the actual speed varies during the journey, even if the average speed is calculated over time.

Q244. Describe a method for measuring the speed of a toy car on a ramp in a lab.
Answer: Use a stopwatch to time how long the toy car takes to travel a known distance on the ramp. Measure the distance with a ruler, then use the formula: speed = distance ÷ time. Repeat for accuracy and take an average.

Q245. A child runs 30 m in 10 s. Calculate their average speed.
Answer: Speed = distance ÷ time = 30 m ÷ 10 s = 3 m/s. So, the child's average speed is 3 metres per second over the 10 seconds.

Q246. Give a typical value for the speed of sound in air and explain why it can vary.
Answer: The typical speed of sound in air is about 330 m/s. It can vary with temperature, humidity, and air pressure. Warmer air usually allows sound to travel faster due to higher energy of air particles.

Q247. What instruments are needed to measure the speed of a moving object accurately?
Answer: A stopwatch or timer is needed to measure time, and a ruler or measuring tape is needed for distance. For higher accuracy, motion sensors, photogates, or GPS can also be used depending on the experiment or object.

Q248. How can you use a stopwatch and a metre ruler to calculate walking speed?
Answer: Measure a fixed distance using a metre ruler, for example, 10 m. Use the stopwatch to time how long the person takes to walk that distance. Then apply speed = distance ÷ time to find their walking speed.

Q249. A person cycles 9 km in 30 minutes. Convert units and calculate average speed in m/s.
Answer: Convert 9 km to 9000 m and 30 minutes to 1800 s. Speed = 9000 ÷ 1800 = 5 m/s. So, the person's average cycling speed is 5 metres per second.

Q250. What are the SI units for distance, speed, and time?
Answer: The SI unit for distance is the metre (m), for speed it is metres per second (m/s), and for time it is the second (s). These standard units are used to ensure consistency in physics calculations.

Q251. A horse runs at 8 m/s for 15 s. What is the total distance it covers?
Answer: 120 metres
Solution:
Distance = Speed × Time
Distance = 8 m/s × 15 s
Distance = 120 m

Q252. A person walks 1.2 km in 20 minutes. Find their average speed in m/s.
Answer: 1 m/s
Solution:
Convert distance: 1.2 km = 1200 m
Convert time: 20 minutes = 20 × 60 = 1200 s
Speed = Distance ÷ Time

Speed = 1200 m ÷ 1200 s
Speed = 1 m/s

Q253. Why might two people running the same distance take different times?
Answer: Because their running speeds or conditions differ. One may be faster due to better fitness, while the other may slow down due to fatigue or obstacles.

Q254. If a sprinter accelerates and then decelerates, how would you calculate their average speed over the race?
Answer: Use the formula: Average Speed = Total Distance ÷ Total Time.
Acceleration or deceleration doesn't affect how average speed is calculated.

Q255. A car travels at 60 km/h for 2 hours. What is the total distance in km and m?
Answer: 120 km or 120,000 m
Solution:
Distance = Speed × Time
Distance = 60 km/h × 2 h
Distance = 120 km
Convert to metres: 120 km = 120 × 1000 = 120,000 m

Q256. A drone flies 300 m east and 400 m north. Calculate its displacement using Pythagoras' theorem.
Answer: 500 m
Solution:
$\text{Displacement}^2 = (300\ \text{m})^2 + (400\ \text{m})^2$
$\text{Displacement}^2 = 90000 + 160000$
$\text{Displacement}^2 = 250000$
Displacement = $\sqrt{250000}$
Displacement = 500 m

Q257. Explain why knowing displacement is important in navigation systems.
Answer: Displacement tells the shortest straight-line path between two points. Navigation systems use it to provide direct and efficient routes, which saves time and energy.

Q258. How do you determine the direction of displacement on a graph?
Answer: Identify the starting and ending points.
Draw a straight line connecting them.
Measure the angle or direction of this line relative to a reference axis.

Q259. A bird flies in a straight line for 2.5 km south. What is the displacement and distance?
Answer: Both displacement and distance are 2.5 km
Explanation: Since the bird flies in a straight line in one direction, the total distance and the straight-line displacement are the same.

Q260. Explain how ratio reasoning can be used to convert km/h to m/s.
Answer:
1 km = 1000 m
1 hour = 3600 s
So, 1 km/h = 1000 m ÷ 3600 s = 1 km/h = 1 ÷ 3.6 m/s
Therefore, to convert km/h to m/s, divide the value by 3.6

Q261. Convert a speed of 72 km/h to m/s using proportional reasoning.
Answer: 20 m/s
Solution:
Speed in m/s = 72 ÷ 3.6
Speed = 20 m/s

Q262. A vehicle covers 100 m in 8 s. Calculate its speed.
Answer: 12.5 m/s
Solution:
Speed = Distance ÷ Time
Speed = 100 m ÷ 8 s
Speed = 12.5 m/s

Q263. A person jogs at 2.5 m/s for 12 minutes. What is the total distance covered in metres and kilometres?
Answer: 1800 m or 1.8 km
Solution:
Convert time: 12 minutes = 12 × 60 = 720 s
Distance = Speed × Time
Distance = 2.5 × 720 = 1800 m
Convert to km: 1800 m ÷ 1000 = 1.8 km

Q264. Compare the distance and displacement of a person walking in a circle back to the start.
Answer: Distance is the length of the circular path walked.
Displacement is 0 because the person ends up at the starting point, meaning there's no change in position.

Q265. Describe a real-life scenario where displacement remains zero but distance is large.
Answer: A runner completing multiple laps on a circular track and returning to the starting point has zero displacement, even though they've covered a large total distance.

Q266. A car travels north for 10 km, then turns east for 10 km. Find its displacement.
Answer: 14.14 km (approximately)
Solution:
Displacement² = (10 km)² + (10 km)²
Displacement² = 100 + 100 = 200
Displacement = √200 = 14.14 km

Q267. How would you estimate the speed of a cyclist using a GPS device?
Answer: Measure the total distance using GPS.
Record the time taken.
Speed = Distance ÷ Time
The GPS provides both values automatically for quick calculation.

Q268. A moving object travels 120 m in 12 s, then 60 m in 4 s. Calculate the total average speed.
Answer: 11.25 m/s
Solution:
Total distance = 120 m + 60 m = 180 m
Total time = 12 s + 4 s = 16 s
Average speed = 180 m ÷ 16 s = 11.25 m/s

Q269. Describe how wind speed can affect the ground speed of an aircraft.
Answer: Tailwind increases ground speed, headwind reduces it.
Crosswinds can push the aircraft sideways, altering direction.
Overall, wind can change both speed and path over the ground.

Q270. Why do scientists prefer SI units when calculating speed and distance?
Answer: SI units are standardised, universally accepted, and reduce confusion. They allow scientists across the world to communicate and compare data clearly and consistently.

Q271. A truck moves 800 m in 40 s, then stops for 20 s, then moves 400 m in 20 s. Find average speed over entire time.
Answer: 15 m/s
Solution:
Total distance = 800 m + 400 m = 1200 m
Total time = 40 s + 20 s + 20 s = 80 s
Average speed = 1200 m ÷ 80 s = 15 m/s

Q272. If the speed of sound is 330 m/s, how far does sound travel in 3 seconds?
Answer: 990 m
Solution:
Distance = Speed × Time
Distance = 330 m/s × 3 s = 990 m

Q273. A ship sails 100 km in 5 hours. What is its speed in m/s?
Answer: 5.56 m/s
Solution:
Convert 100 km = 100,000 m
Convert 5 hours = 5 × 3600 = 18000 s
Speed = 100,000 m ÷ 18000 s ≈ 5.56 m/s

Q274. Explain how to use a distance-time graph to determine speed.
Answer: On a distance-time graph, speed is the slope of the line.
Choose two points on the line.
Find the difference in distance (Δy) and time (Δx).
Speed = $\Delta y \div \Delta x$

Q275. Describe how the concept of vector and scalar quantities applies to displacement and speed.
Answer: Speed is a scalar—it has only magnitude.
Displacement is a vector—it has both magnitude and direction.
Vectors show both how far and in what direction, scalars only show how much.

Q276. Explain the difference between velocity and speed using an example.
Answer: Velocity is speed in a given direction, while speed only tells how fast something is moving. For example, if a car moves at 20 m/s to the north, its speed is 20 m/s and its velocity is 20 m/s north. But if another car moves at 20 m/s to the south, both cars have the same speed, but different velocities because they are going in different directions.

Q277. Why is velocity considered a vector quantity while speed is not?
Answer: Velocity is a vector because it includes both magnitude and direction. Speed only has magnitude and does not consider direction, so it is a scalar. For example, moving at 10 m/s east and 10 m/s west are different velocities but the same speed. The direction makes velocity a vector.

Q278. Describe how displacement differs from distance, using a real-life example.
Answer: Displacement is the straight-line distance from the starting point to the endpoint, including direction. Distance is the total length of the path taken. If you walk 5 km in a straight line east and then 5 km back west to your start, your distance is 10 km, but your displacement is 0 because you end up where you started.

Q279. A car travels in a straight line and returns to its starting point. What is its displacement and how does it differ from the distance travelled?
Answer: The displacement is zero because the car ends up where it started. The distance travelled is the total length of the path. If the car goes 50 km away and then comes back 50 km, the distance is 100 km, but the displacement is 0 because the start and end points are the same.

Q280. How can an object have constant speed but changing velocity?
Answer: An object moving in a circle at constant speed has changing velocity because the direction is continuously changing. Even if the speed (magnitude) remains the same, a change in direction means the velocity changes, as velocity is a vector that depends on both speed and direction.

Q281. A person walks around a circular track at constant speed. Explain why their velocity is not constant.
Answer: Their velocity is not constant because direction keeps changing at every point along the

circular path. Even though the speed remains the same, velocity includes direction, so changing direction results in changing velocity.

Q282. Give one example of a situation where speed remains the same but velocity changes.
Answer: A car turning around a bend at a steady 30 km/h has constant speed, but its velocity is changing because the direction is changing as it turns. This change in direction makes the velocity change even if the speed stays the same.

Q283. Why is direction important when calculating velocity?
Answer: Direction is important in velocity because velocity is a vector. It tells not just how fast something is moving, but also where it's going. Two objects can have the same speed but different velocities if they are moving in different directions.

Q284. A cyclist moves north at 5 m/s and another moves south at 5 m/s. Explain whether their velocities are the same.
Answer: No, their velocities are not the same. Although their speeds are equal, their directions are opposite. Since velocity depends on both speed and direction, one is 5 m/s north and the other is 5 m/s south, so their velocities differ.

Q285. Describe a situation where an object's velocity is zero but it still has a speed.
Answer: This situation cannot occur. If an object has speed, it must be moving, and therefore its velocity will not be zero. However, if the object is at rest, both its speed and velocity are zero. Velocity can only be zero if speed is zero and there is no movement.

Q286. What does the slope of a straight line on a distance–time graph represent?
Answer: The slope of a straight line on a distance–time graph represents the speed of the object. A steeper slope means a higher speed, while a flatter slope means a lower speed. If the line is straight and angled, the object is moving at a constant speed.

Q287. Explain how to find the speed of an object from a distance–time graph.
Answer: To find speed, calculate the gradient (slope) of the graph. Pick two points on the line, subtract the initial distance from the final distance to get the change in distance. Then subtract the initial time from the final time to get the change in time. Divide the change in distance by the change in time. Speed = Distance ÷ Time.

Q288. How would the distance–time graph look for an object that is stationary?
Answer: The graph would show a horizontal line. This means that distance is not changing with time, which indicates that the object is not moving and its speed is zero.

Q289. A distance–time graph has a steep slope. What does that tell you about the object's speed?
Answer: A steep slope on a distance–time graph shows that the object is covering a large distance in a short time, meaning it is moving fast. The steeper the line, the greater the speed.

Q290. What would a curved line on a distance–time graph indicate?
Answer: A curved line shows that the object's speed is changing—it is either accelerating or decelerating. If the curve gets steeper, the object is speeding up. If the curve becomes flatter, the object is slowing down.

Q291. How can you use a tangent on a curved distance–time graph to find speed at a certain point?
Answer: Place a tangent (a straight line that just touches the curve) at the point of interest. Find the gradient of that tangent line by selecting two points on it and calculating the change in distance divided by the change in time. This gradient gives the instantaneous speed at that point.

Q292. Describe how to draw a distance–time graph from a set of time and distance measurements.
Answer: First, label the axes: time on the x-axis and distance on the y-axis. Plot each time and distance pair as a point. Then, connect the points with straight or curved lines depending on the motion. Make sure to scale both axes properly for accuracy.

Q293. Why is it important to label axes correctly on a distance–time graph?
Answer: Correctly labelling axes helps readers understand what the graph represents. Without proper labels, the data can be misinterpreted. It also helps identify what units are being used and makes the graph readable and meaningful.

Q294. What information can be gathered by interpreting the shape of a distance–time graph?
Answer: The shape tells us whether the object is moving at a constant speed, accelerating, decelerating, or stationary. A straight angled line means constant speed, a horizontal line means no motion, and a curved line shows changing speed.

Q295. How would the graph look for an object that moves away and then comes back to the starting point?
Answer: The graph would first rise as the object moves away, then fall as it returns. The final point would be at the same level as the starting point, showing that the total displacement is zero, even if the distance covered is not.

Q296. A student measures the time taken to walk different distances. How should they use this data to draw a distance–time graph?
Answer: The student should plot time on the x-axis and distance on the y-axis. Each measurement pair becomes a point on the graph. After plotting all points, they can connect them to show the motion and then analyse the slope to understand speed changes.

Q297. How does the gradient of a distance–time graph relate to the object's motion?
Answer: The gradient tells us the speed. A constant gradient means constant speed. A steeper gradient means faster motion. A changing gradient shows that speed is changing—either increasing or decreasing depending on whether the slope gets steeper or flatter.

Q298. Why does motion in a circle count as acceleration even if speed is constant?
Answer: Because the direction of the object is constantly changing, and velocity depends on both speed and direction. Any change in velocity, even just in direction, means the object is accelerating. So, circular motion involves constant acceleration due to changing direction.

Q299. Describe how distance–time graphs can help compare the motion of two different objects.
Answer: By comparing the slopes of their lines. The object with the steeper line is moving faster. If one line is horizontal, that object is not moving. Graphs can also show which object started first, changed speed, or returned to the starting point.

Q300. What does a horizontal line on a distance–time graph tell you about the object's motion?
Answer: A horizontal line means the object is not moving—its distance from the start does not change over time. This shows the object is stationary and its speed is zero during that time period.

Q301. Define acceleration and state its SI unit.
Answer: Acceleration is the rate of change of velocity per unit time. It tells us how quickly an object speeds up or slows down. If an object's velocity increases or decreases over a certain time, we can say it is accelerating. The SI unit of acceleration is metres per second squared (m/s^2).

Q302. A car increases its velocity from 10 m/s to 30 m/s in 5 seconds. Write an equation to calculate its acceleration.
Answer: $a = (v - u) \div t$
Solution:
Initial velocity, $u = 10$ m/s
Final velocity, $v = 30$ m/s
Time, $t = 5$ s
$a = (30 - 10) \div 5 = 20 \div 5 = 4\ m/s^2$

Q303. How is deceleration different from acceleration?
Answer: Deceleration is the opposite of acceleration. While acceleration means an object is increasing its velocity, deceleration means it is slowing down or reducing its velocity. It is a form of acceleration but in the direction opposite to motion, which is why its value is negative.

Q304. Describe how you would estimate the acceleration of a cyclist moving from rest to top speed in a few seconds.
Answer: To estimate the acceleration, measure how long it takes for the cyclist to go from rest (0 m/s) to top speed. Record the final speed and the time taken. Then use the formula: acceleration = change in velocity ÷ time taken. This gives an approximate value for the cyclist's acceleration.

Q305. What does a straight sloping line on a velocity–time graph show about an object's motion?
Answer: A straight sloping line on a velocity–time graph shows that the object is accelerating at a

constant rate. The slope or gradient of the line tells us how fast the velocity is changing. If the slope goes upward, it is speeding up. If it goes downward, the object is slowing down.

Q306. A train slows down from 25 m/s to 5 m/s in 10 seconds. What type of acceleration is this and how would you calculate it?
Answer: This is deceleration because the speed is decreasing.
Solution:
Initial velocity, u = 25 m/s
Final velocity, v = 5 m/s
Time = 10 s
$a = (v - u) \div t = (5 - 25) \div 10 = -20 \div 10 = -2\ m/s^2$
The negative value confirms it is deceleration.

Q307. Explain how to find acceleration from a velocity–time graph.
Answer: To find acceleration, calculate the gradient (slope) of the line. Choose two points on the graph. Find the change in velocity and divide it by the change in time. If the line is straight, the acceleration is constant. If the slope is steep, the acceleration is high.

Q308. What is the significance of a horizontal line on a velocity–time graph?
Answer: A horizontal line means the object is moving at a constant velocity. There is no change in speed over time, so the acceleration is zero. This shows that the object is not speeding up or slowing down.

Q309. Describe how to draw a velocity–time graph for an object that starts from rest and accelerates uniformly.
Answer: Label the x-axis as time and the y-axis as velocity. Since the object starts from rest, the line begins at the origin (0,0). If it accelerates uniformly, draw a straight line sloping upwards from the origin. The slope represents constant acceleration.

Q310. Explain how to calculate the distance travelled using the area under a velocity–time graph.
Answer: The area under the velocity–time graph represents the distance travelled. If the graph is a straight line, calculate the area using the formula for a triangle or rectangle, depending on the shape. For curved lines, count squares or use integration if required.

Q311. What does the area under a straight sloping line in a velocity–time graph represent?
Answer: It represents the total distance travelled by the object. If the line forms a triangle, use the formula ½ × base × height to find the area. This area gives the distance covered while the object is accelerating.

Q312. A body accelerates uniformly from 0 to 20 m/s in 4 seconds. How would you calculate its acceleration and distance covered?
Answer:
Solution:

Initial velocity, u = 0
Final velocity, v = 20 m/s
Time = 4 s
Acceleration = (v - u) ÷ t = (20 - 0) ÷ 4 = 5 m/s²
Distance = ½ × (u + v) × t = ½ × (0 + 20) × 4 = 10 × 4 = 40 m

Q313. State the equation used to calculate distance when an object has uniform acceleration and describe what each symbol represents.
Answer: The equation is:
$s = \frac{1}{2} \times (u + v) \times t$
Where:
s = distance in metres
u = initial velocity in m/s
v = final velocity in m/s
t = time in seconds
This equation is used to find the distance covered under uniform acceleration.

Q314. How can you use the equation v2−u2=2asv^2 - u^2 = 2asv2−u2=2as to calculate the distance travelled by an object?
Answer: Rearrange the equation to solve for distance:
$s = (v^2 - u^2) \div (2a)$
Use known values for initial velocity (u), final velocity (v), and acceleration (a). Plug them into the formula to find the distance (s) covered during the motion.

Q315. Describe a situation in which an object falls freely and reaches terminal velocity.
Answer: A skydiver jumping from a plane initially accelerates due to gravity. As they fall, air resistance increases. Eventually, the force of air resistance equals the force of gravity, so acceleration stops. The skydiver then falls at a constant speed called terminal velocity.

Q316. What is terminal velocity and when does it occur during a fall?
Answer: Terminal velocity is the constant speed reached when the downward force of gravity is balanced by the upward force of air resistance. It occurs after the object has been falling for a while and no longer accelerates.

Q317. Why does a falling object eventually stop accelerating in a fluid like air or water?
Answer: Because as the object speeds up, resistance from the fluid increases. Eventually, this resistance becomes equal to the force of gravity, resulting in zero net force. Without a net force, the object no longer accelerates and moves at a constant speed.

Q318. Sketch and describe the velocity–time graph of a skydiver before and after opening the parachute.
Answer: Before opening the parachute, the graph shows a steep rise that levels off when terminal velocity is reached. After opening the parachute, there's a sharp drop in velocity, followed by a new, lower constant velocity line showing the slower terminal velocity with the parachute.

Q319. Explain how air resistance affects the motion of a falling object.
Answer: Air resistance acts against gravity and slows the object down. As the object speeds up, air resistance increases. This reduces the net force, decreasing the acceleration. Eventually, the object reaches a constant speed when forces balance—this is terminal velocity.

Q320. What forces act on an object falling freely under gravity and how do they change as it falls?
Answer: The main forces are gravity (pulling down) and air resistance (pushing up). At first, gravity is stronger, so the object accelerates. As speed increases, air resistance grows. Eventually, both forces become equal, and the object stops accelerating.

Q321. Why does acceleration remain constant during free fall near the Earth's surface in the absence of air resistance?
Answer: Because the only force acting is gravity, which is constant near Earth's surface. There is no air resistance to oppose the motion, so the object accelerates uniformly at about $9.8\ m/s^2$.

Q322. Describe how to conduct a simple experiment to show the effect of air resistance on falling objects.
Answer: Drop two objects of the same mass but different surface areas (e.g. a crumpled paper and a flat sheet) from the same height. The flat one falls slower due to more air resistance. Measure the time each takes to fall to observe the effect of air resistance.

Q323. What measurements would you take to calculate acceleration during an experiment with a model parachute?
Answer: Measure the time it takes for the parachute to fall a known distance. Also, record the initial and final velocities if possible. Use these values to calculate acceleration using the formula: acceleration = change in velocity ÷ time.

Q324. What is the value of acceleration due to gravity on Earth and how is it used in calculations?
Answer: The acceleration due to gravity on Earth is about $9.8\ m/s^2$. This value is used when calculating the motion of freely falling objects. For example, if an object falls for 2 seconds, its velocity is $9.8 \times 2 = 19.6\ m/s$.

Q325. How can you tell from a velocity–time graph when an object has reached terminal velocity?
Answer: Terminal velocity is shown as a horizontal line on a velocity–time graph after a period of increasing speed. This line indicates constant velocity, meaning the object is no longer accelerating and has reached terminal velocity.

Q326. State Newton's First Law in your own words.
Answer: Newton's First Law says that an object will stay at rest or keep moving at the same speed and in the same direction unless a resultant force acts on it. This means if no unbalanced force is

applied, the motion doesn't change. So, a stationary object remains still, and a moving object keeps moving in a straight line at a constant speed.

Q327. A cyclist travels at a steady speed along a level road. What can you say about the forces acting on the cyclist?
Answer: The driving force from the pedals is balanced by resistive forces like friction and air resistance. Since the cyclist is moving at a steady speed, the resultant force is zero. According to Newton's First Law, this is why the speed and direction remain unchanged.

Q328. Explain why a book resting on a table stays still even though gravity acts on it.
Answer: Gravity pulls the book down, but the table provides an equal and opposite upward force called the normal reaction. These forces are balanced, resulting in zero net force. So, there is no change in motion, and the book remains at rest.

Q329. Describe what happens to the motion of a car if the driving force equals the resistive forces.
Answer: If the driving force and resistive forces are equal, there is no resultant force. According to Newton's First Law, the car will continue to move at a constant speed and in the same direction. Its velocity does not change.

Q330. Give one everyday example where an object keeps moving at the same speed and direction because no resultant force acts on it.
Answer: A puck sliding on a smooth ice surface can keep moving at constant speed and direction because there's little friction. If no other forces act on it, the puck continues to slide without slowing down or turning.

Q331. What is inertia, and how does it relate to Newton's First Law?
Answer: Inertia is the tendency of an object to stay in its current state—either at rest or moving with constant velocity. It means objects resist changes in their motion. Newton's First Law is based on this concept, explaining that motion only changes if a resultant force is applied.

Q332. How would you show with a simple experiment that motion continues without a push once friction is removed?
Answer: Place a trolley on a smooth ramp and give it a push. After removing your hand, the trolley keeps moving. If the surface is nearly frictionless, it will continue at a steady speed. This shows that in the absence of resistive forces, motion continues without further force.

Q333. Explain why passengers feel pushed back into their seats when a bus starts moving suddenly.
Answer: When the bus accelerates, the passengers' bodies want to stay in the same state (at rest) due to inertia. The seat pushes them forward, but they feel as if they're being pushed back. This sensation is due to their resistance to the sudden change in motion.

Q334. A hockey puck slides across smooth ice and slows down. Which force causes the puck to break Newton's First Law?

Answer: The friction between the puck and the ice causes it to slow down. This unbalanced force acts in the opposite direction to its motion, changing its velocity and causing it to decelerate.

Q335. Write the equation that links force, mass, and acceleration, and name each quantity with its unit.

Answer: The equation is: $F = m \times a$
F is force in newtons (N)
m is mass in kilograms (kg)
a is acceleration in metres per second squared (m/s^2)
This formula is Newton's Second Law and shows how force depends on both mass and acceleration.

Q336. If the mass of an object doubles and the force stays the same, how does its acceleration change?

Answer: Since acceleration is inversely proportional to mass ($a = F/m$), if the mass doubles and force stays the same, the acceleration becomes half. A heavier object accelerates less under the same force.

Q337. A van of mass 1 500 kg accelerates at 2 m/s^2. Calculate the resultant force needed.

Solution:
$F = m \times a$
$F = 1\,500 \times 2 = 3\,000$ N

Answer: The van needs a force of 3 000 newtons to accelerate at 2 m/s^2.

Q338. Explain why a lighter car can accelerate faster than a heavier truck when the same force is applied.

Answer: According to Newton's Second Law, acceleration depends on the mass of the object. For the same force, the object with less mass will have more acceleration. So, a lighter car speeds up more quickly than a heavier truck.

Q339. Define inertial mass, and write the formula that shows how it is measured.

Answer: Inertial mass measures how difficult it is to change an object's velocity. It shows how much an object resists acceleration when a force is applied. It is calculated as:
Inertial mass = Force ÷ Acceleration

Q340. A scooter rider says, "My bike feels heavier when I carry a passenger." Explain this using the idea of inertial mass.

Answer: With a passenger, the total mass of the scooter and rider increases. This means more force is needed to achieve the same acceleration. The increased inertial mass makes it harder to change the bike's speed, so it feels heavier.

Q341. Give an example of a situation on the road where a large acceleration is needed, and estimate the forces involved.

Answer: A car overtaking on a highway needs to speed up quickly. If the car has a mass of 1 000 kg and accelerates at about 3 m/s², the force needed is F = m × a = 1 000 × 3 = 3 000 N. This shows how a strong engine is needed for such manoeuvres.

Q342. A bus has a mass of 8 000 kg and needs to reach 20 m/s in 10 s. Estimate the size of the driving force, showing your method.

Solution:
Acceleration = change in velocity ÷ time = 20 ÷ 10 = 2 m/s^2
Force = mass × acceleration = 8 000 × 2 = 16 000 N
Answer: The bus needs a driving force of about 16 000 newtons.

Q343. A sports car can go from 0 m/s to 30 m/s in 4 s. Explain why the force engine designers can supply must be high.

Answer: To achieve a high acceleration in a short time, a large force is needed. Using F = m × a, we see that for the same mass, faster acceleration requires more force. That's why powerful engines are built into sports cars for quick speed increases.

Q344. How does using the symbol ∝ help show the link between acceleration and force in Newton's Second Law?

Answer: The symbol ∝ means "is proportional to." Writing a ∝ F shows that acceleration increases when force increases. It also shows that if mass stays the same, more force gives more acceleration, which matches Newton's Second Law.

Q345. An object has a mass of 5 kg and accelerates at 0.5 m/s². Estimate the force acting on it using the approximate sign ~.

Solution:
F ≈ m × a = 5 × 0.5 = 2.5 N
Answer: The approximate force acting on the object is ~2.5 newtons.

Q346. Describe how you could use motion sensors to test Newton's Second Law in a classroom.

Answer: Attach a motion sensor to a trolley and apply different known forces using weights. Measure the acceleration each time. Record mass, force, and acceleration. Plot results to see that acceleration is proportional to force and inversely proportional to mass.

Q347. Why do large lorries need more powerful brakes than small cars? Answer in terms of force and mass.

Answer: Lorries have greater mass, so they have more inertia. To slow down the same amount in the same time, they need more force. Bigger brakes provide the extra force needed to decelerate heavy vehicles safely.

Q348. A skateboarder pushes off the ground and quickly speeds up. Use Newton's Second Law to explain the change in motion.

Answer: The push provides a force on the skateboarder. According to F = m × a, this force causes acceleration. Since the skateboarder's mass is small, even a modest force results in a noticeable acceleration.

Q349. Explain how seat belts help passengers obey Newton's First Law during a sudden stop.
Answer: When a car stops suddenly, passengers tend to keep moving forward due to inertia. Seat belts provide a force that stops them safely by changing their motion along with the car, preventing injuries that could happen from continuing forward.

Q350. Describe what happens to the forces on a skydiver just after they jump and before reaching terminal velocity.
Answer: At first, gravity pulls the skydiver down with little air resistance, so they accelerate. As speed increases, air resistance grows. Eventually, air resistance equals the force of gravity. At that point, there is no net force and acceleration stops—the skydiver reaches terminal velocity.

Q351. Two friends on skateboards push against each other and roll apart. Explain why they move in opposite directions with equal force.
Answer: When the friends push against each other, each one exerts a force on the other. According to Newton's Third Law, for every action, there is an equal and opposite reaction. So, the force that one friend applies is matched by an equal force in the opposite direction from the other friend. As they are on skateboards, which have low friction, they roll apart in opposite directions with equal and opposite forces.

Q352. A swimmer pushes the water backwards while swimming. Describe the force that makes the swimmer move forwards.
Answer: When a swimmer pushes water backwards using their arms and legs, the water pushes back with an equal and opposite force. This reaction force from the water pushes the swimmer forward. This is Newton's Third Law in action: the swimmer applies a backward force to the water, and the water applies a forward force on the swimmer.

Q353. A gun recoils when it fires a bullet. State and explain the pair of forces involved.
Answer: When a bullet is fired from a gun, the gun exerts a force on the bullet to push it forward. At the same time, the bullet exerts an equal and opposite force on the gun, causing it to recoil backward. These two forces are equal in size and opposite in direction, demonstrating Newton's Third Law of motion.

Q354. How does Newton's Third Law apply when a book rests on a table?
Answer: When a book is resting on a table, the book exerts a downward force on the table due to its weight (gravity acting on it). The table reacts by exerting an equal and opposite upward force on the book. These forces are action and reaction pairs: equal in magnitude and opposite in direction. This balance keeps the book at rest.

Q355. A car of mass 1 200 kg brakes with a constant force of 6 000 N. Calculate the car's deceleration.
Answer:

Solution:
Formula: $F = m \times a$
Rearranged: $a = F \div m$
$a = 6000\ N \div 1200\ kg$
$a = 5\ m/s^2$
Answer: The car's deceleration is $5\ m/s^2$.

Q356. Explain why increasing a car's speed increases its braking distance for the same braking force.
Answer: When a car travels at a higher speed, it has more kinetic energy. Since braking involves removing this energy, the brakes must do more work to stop the car. Because the braking force stays the same, it takes more distance to remove the extra energy. As a result, the braking distance increases more than proportionally with speed. For example, doubling the speed can quadruple the braking distance.

Q357. Describe what is meant by the thinking distance of a driver.
Answer: Thinking distance is the distance a vehicle travels during the time it takes for the driver to react to a hazard and begin braking. It depends on the driver's reaction time and the speed of the vehicle. If the reaction time is longer or the car is moving faster, the thinking distance will be greater. It is one part of the total stopping distance.

Q358. A driver has a reaction time of 0.8 s and is travelling at 25 m/s. Calculate the thinking distance.
Solution:
Formula: thinking distance = speed × reaction time
thinking distance = 25 m/s × 0.8 s = 20 m
Answer: The thinking distance is 20 metres.

Q359. List two factors that can increase a driver's reaction time.
Answer: Two factors that can increase a driver's reaction time are alcohol consumption and tiredness. Both of these affect the brain's ability to process information quickly, making the driver slower to react to hazards, which in turn increases the thinking distance and the overall stopping distance.

Q360. A wet road surface can double the braking distance. Explain why.
Answer: A wet road reduces the friction between the tyres and the surface. This means that when the brakes are applied, the tyres cannot grip the road effectively, making it harder to stop the car. As a result, the car takes longer to slow down and stop, increasing the braking distance—often doubling it compared to dry conditions.

Q361. A van stops in 60 m from 30 m/s. If the thinking distance is 18 m, find the braking distance.
Solution:
Stopping distance = thinking distance + braking distance

Braking distance = stopping distance – thinking distance
Braking distance = 60 m – 18 m = 42 m
Answer: The braking distance is 42 metres.

Q362. Draw and label the forces acting on a cyclist who is moving at a steady speed.
Answer: At a steady speed, four forces act on the cyclist: the weight acts downward due to gravity, the normal contact force acts upward from the ground, the driving force from the pedals moves the cyclist forward, and air resistance (or drag) and friction oppose the motion. The forward and backward forces are balanced, as are the upward and downward forces.

Q363. Explain how the forces on a parachutist change from jumping out of a plane to reaching terminal speed.
Answer: When the parachutist first jumps, the only force is gravity, pulling them downwards, causing them to accelerate. As they fall, air resistance increases. Eventually, air resistance equals the weight, and the forces become balanced. At this point, they stop accelerating and fall at a constant speed called terminal velocity.

Q364. A truck travelling at 20 m/s needs to stop in an emergency. Give two ways the stopping distance could be reduced without lowering speed.
Answer: Two ways to reduce stopping distance without reducing speed are improving the road surface (for better tyre grip) and using advanced braking systems like ABS. Both methods increase the friction between tyres and road or improve braking efficiency, helping the vehicle stop in a shorter distance.

Q365. Describe a simple school experiment to measure human reaction time using a ruler drop test.
Answer: One student holds a ruler vertically, and another places their fingers at the bottom ready to catch it. Without warning, the first student drops the ruler, and the second catches it as quickly as possible. The distance the ruler falls before being caught is used to calculate the reaction time using a formula derived from the equation for free fall: $d = 0.5 \times g \times t^2$.

Q366. Explain why drinking alcohol before driving is dangerous using the idea of reaction time.
Answer: Alcohol slows down the brain's ability to process information and respond. This increases the driver's reaction time, which means the vehicle travels a greater distance before braking begins. As a result, the thinking distance increases, and the total stopping distance becomes longer, raising the risk of collisions.

Q367. A bicycle and a lorry collide. Use Newton's Third Law to describe the forces on each vehicle during the collision.
Answer: During the collision, the bicycle exerts a force on the lorry, and the lorry exerts an equal and opposite force on the bicycle. These forces are the same in size but opposite in direction. However, because the bicycle has much less mass, it will experience a much greater change in motion, resulting in more noticeable damage or acceleration.

Q368. A 65 kg runner pushes the ground with a force of 700 N. What force does the ground exert on the runner?
Answer: According to Newton's Third Law, the ground will exert an equal and opposite force of 700 N on the runner. This is the force that propels the runner forward. The two forces are part of an action–reaction pair: the runner pushes the ground backward, and the ground pushes the runner forward with the same force.

Q369. Explain why passengers lean forwards when a bus brakes suddenly.
Answer: When the bus brakes suddenly, the unbalanced braking force slows the bus down, but the passengers continue moving forward due to inertia. There is no forward force acting on them to stop them at the same rate as the bus, so they appear to lurch forward. Seat belts help prevent this by applying a force that slows them down with the bus.

Q370. A car travels at 15 m/s and has a total stopping distance of 25 m. Estimate the stopping distance if the speed doubles, assuming similar conditions.
Answer: Stopping distance increases with the square of speed. If the speed doubles from 15 m/s to 30 m/s, the stopping distance becomes 4 times greater. So, the estimated stopping distance is 25 m × 4 = 100 m. This shows that stopping distances grow rapidly with speed increases.

Q371. Describe how mobile phone use can affect the thinking distance of a driver.
Answer: Using a mobile phone while driving distracts the driver, making it harder to focus on the road. This distraction delays their reaction to hazards, increasing their reaction time. As a result, the car travels further before the brakes are applied, increasing the thinking distance and overall stopping distance.

Q372. Explain the purpose of anti-lock braking systems in cars in terms of stopping distance.
Answer: Anti-lock braking systems (ABS) prevent the wheels from locking when brakes are applied sharply. Locked wheels slide rather than roll, reducing friction and control. ABS allows the driver to maintain steering and maximises friction with the road surface. This can shorten braking distance and help avoid skidding, especially on slippery surfaces.

Q373. A driver spots an obstacle 40 m ahead while driving at 22 m/s. The braking distance at this speed is 27 m. Calculate the minimum reaction time the driver must have to avoid a crash.
Solution:
Thinking distance = total stopping distance – braking distance = 40 m – 27 m = 13 m
Reaction time = thinking distance ÷ speed = 13 m ÷ 22 m/s ≈ 0.59 s
Answer: The minimum reaction time the driver must have to avoid a crash is approximately 0.59 s.

Q374. Give two reasons why older tyres can increase braking distance.
Answer: Older tyres have worn-out treads which reduce grip on the road, especially in wet conditions. They are also often hardened or cracked, which reduces their flexibility and friction. Both factors lower the tyre's ability to slow the vehicle down effectively, increasing the braking distance.

Q375. A ball is thrown at a wall and bounces back. Use Newton's Third Law to explain the ball's change of direction.

Answer: When the ball hits the wall, it exerts a force on the wall. By Newton's Third Law, the wall exerts an equal and opposite force back on the ball. This reaction force changes the direction of the ball's motion, causing it to bounce back. The harder the ball hits, the greater the force exerted by the wall.

Q376. State what is meant by an action–reaction force pair, giving one everyday example.

Answer: An action–reaction force pair refers to two forces that are equal in size but opposite in direction, acting on two different objects. For example, when you jump off the ground, your legs push down on the Earth (action), and the Earth pushes you upward (reaction). These two forces happen at the same time and are part of Newton's Third Law.

Q377. Explain why heavy trucks need longer distances to stop compared with small cars at the same speed.

Answer: Heavy trucks have much greater mass than small cars, so at the same speed they possess far more kinetic energy, because kinetic energy equals one-half the mass multiplied by the speed squared. Brakes remove kinetic energy by friction, and the amount of energy that can be converted to heat per second is limited by the size of the brake discs, the area of the brake pads, and the grip between tyres and road. Since the braking force is restricted by tyre friction that depends mainly on the weight distribution and the condition of the road surface, a truck's brakes must dissipate much more energy than a car's while delivering a similar coefficient of friction. The result is that the truck needs a longer distance for its brakes to do the extra work required to absorb this energy without overheating or locking the wheels. Suspension design and longer air-brake response times can also add distance, so overall a heavy truck requires significantly more road to come to a safe halt.

Q378. A traffic safety chart shows speed on the x-axis and total stopping distance on the y-axis. Describe how you would find the thinking distance from the graph at a given speed.

Answer: First locate the point on the graph that corresponds to the chosen speed on the horizontal axis; read upward until you meet the stopping-distance curve, then note the total stopping distance on the vertical axis. Next consult the same graph or its key to find the braking-distance value for that speed; many charts print a separate curve for braking distance or list it in a table. Finally subtract the braking distance from the total stopping distance: the remainder is the thinking distance. Because thinking distance equals reaction time multiplied by speed, and braking distance depends on vehicle and road factors, this subtraction isolates the distance covered solely during the driver's reaction. If the graph lacks a separate braking curve, use any provided equation or guideline to estimate braking distance before subtracting. This method lets safety analysts identify how human factors alone contribute to overall stopping distance.

Q379. Why does driving while tired pose a similar risk to driving under the influence of alcohol?

Answer: Both fatigue and alcohol slow the brain's information-processing speed, lengthen reaction time, and impair judgment. When tired, the brain struggles to maintain alertness, causing microsleeps—brief lapses in attention that may last a fraction of a second but are enough to miss a hazard altogether. Alcohol similarly depresses the central nervous system, delaying reflexes and lowering concentration. Each condition reduces the driver's ability to gauge speed and distance accurately, leading to delayed braking and steering responses. In both cases, the thinking distance lengthens because the driver's foot reaches the brake pedal later, and the chance of making erroneous decisions such as misjudging a gap or drifting from a lane increases. Studies show that being awake for more than sixteen hours can impair performance to a level comparable with a blood-alcohol concentration over many legal limits. Therefore, tiredness can be just as dangerous as alcohol, even though it is legal, because its cognitive effects mirror those of intoxication.

Q380. Describe how rain on the windscreen can indirectly increase a car's stopping distance.
Answer: Rain falling on the windscreen can scatter and refract light, making it harder for the driver to see clearly. Even with wipers active, lingering droplets cause visual distortion, slowing the driver's ability to detect obstacles or changes in traffic. This visual impairment lengthens reaction time because the brain needs extra milliseconds to interpret blurred images, increasing the thinking distance. Meanwhile, rain also reduces tyre grip on the road, so when the driver finally brakes, the braking distance becomes longer due to lower friction. The combination of extended thinking distance and increased braking distance produces a greater total stopping distance. Additionally, the distraction of adjusting wiper speed or demisters divides attention, further slowing reactions. Thus, even before considering the physical effect of water on the road surface, rain-induced visual difficulty can indirectly make the car travel farther before stopping.

Q381. A student's reaction time is measured three times: 0.32 s, 0.35 s, and 0.30 s. Calculate the mean reaction time.
Solution:
Formula: mean = $(t_1 + t_2 + t_3) \div 3$
mean = (0.32 s + 0.35 s + 0.30 s) ÷ 3
mean = 0.97 s ÷ 3
mean = 0.323 s (rounded to three decimal places)
Answer: The mean reaction time is approximately 0.323 seconds, showing the student's average response speed across the trials and smoothing out small variations in individual measurements.

Q382. Explain why a seat belt reduces injuries using ideas of stopping distance and force.
Answer: When a car crashes, it stops in a very short distance, so without restraint the passenger's body would continue forward at the pre-impact speed until it hits the dashboard or windscreen. A seat belt spreads the stopping process over a longer distance by stretching slightly and allowing the torso to decelerate more gradually. Because force equals change in momentum divided by the time taken, increasing the time and distance of deceleration lowers the peak force on the body. The belt's wide strap also distributes this reduced force across stronger parts of the skeleton, such as the chest and pelvis, avoiding concentrated impacts that could break bones or damage organs. Moreover, seat belts hold occupants in the correct position for airbags to work effectively, preventing secondary collisions within the vehicle interior. By combining longer stopping distance for the body and lower forces, seat belts greatly reduce injury severity in crashes.

Q383. A vehicle of mass 900 kg stops in 5 s from 18 m/s. Calculate the average braking force.
Solution:
Initial momentum $p_i = m \times v = 900\ kg \times 18\ m/s = 16\,200\ kg\ m/s$
Final momentum p_f = 0 (vehicle at rest)
Change in momentum $\Delta p = p_f - p_i = -16\,200\ kg\ m/s$
Braking force $F = \Delta p \div \Delta t = -16\,200\ kg\ m/s \div 5\ s = -3\,240\ N$
(The negative sign shows force acts opposite to motion.)
Answer: The average braking force is 3 240 newtons acting opposite to the direction of travel, enough to remove the vehicle's momentum over the five-second interval.

Q384. Suggest one reason why a graph of speed versus braking distance is nonlinear.
Answer: Braking distance depends on the square of speed because the kinetic energy that the brakes must remove is proportional to speed squared. As speed increases, the required energy rises rapidly, so each extra metre per second adds progressively more distance. This creates a curve that gets steeper at higher speeds rather than forming a straight line. Additional factors like brake fade and tyre heating at high speeds can further accentuate the curvature, confirming the nonlinear relationship.

Q385. Describe how loose gravel on a road affects both thinking and braking distance.
Answer: Loose gravel scatters under tyres, cutting friction dramatically and increasing braking distance because the wheels can skid or roll over shifting stones rather than gripping firm tarmac. Stones striking the underside or pinging off the bodywork create noise and vibration that distract the driver, lengthening reaction time and thus thinking distance. Gravel dust can also obscure road markings, making hazards harder to spot. Therefore both parts of the stopping distance can grow, raising accident risk.

Q386. Explain why reaction times measured with a computer test might differ from those using a ruler drop test.
Answer: Computer tests often present visual or auditory stimuli on a screen, and participants respond by pressing a key, so the measured interval includes the time needed for finger movement and key-press detection. In contrast, a ruler drop test measures the grasp response of the hand and forearm muscles, with gravity accelerating the ruler in a predictable way. Differences in muscle groups, stimulus types, and timing precision mean that the two methods probe slightly different neural pathways and motor actions. Monitor refresh rates and keyboard latency can also introduce small delays or variability. Consequently, computer-based reaction times can be longer or shorter than ruler-based times, even for the same participant, because the physical and technological factors differ.

Q387. A car's stopping distance increases from 45 m to 63 m in heavy rain. Calculate the percentage increase.
Solution:
Increase = 63 m − 45 m = 18 m
Percentage increase = (increase ÷ original) × 100
Percentage increase = (18 m ÷ 45 m) × 100 ≈ 40 %

Answer: The stopping distance rises by about forty percent, illustrating how severely wet conditions can undermine braking performance and extend the distance required to halt safely.

Q388. State two safety features in modern cars that reduce the force on passengers during a crash.

Answer: Airbags inflate rapidly to cushion the body, extending the deceleration distance and spreading forces over a larger area, while crumple zones deform in a controlled way at the front and rear of the vehicle, absorbing kinetic energy before it reaches the passenger compartment. Both features lower peak forces on occupants, making serious injuries less likely.

Q389. A child pushes a toy car and it moves forwards 2 m. Explain, using Newton's Third Law, the interaction between the child's hand and the car.

Answer: When the child's hand pushes backward on the toy car, the car simultaneously pushes forward on the hand with an equal and opposite force, in accordance with Newton's Third Law. Because the child's hand is braced by their body and the floor, it hardly moves, while the lightweight toy car experiences the forward reaction force and accelerates across the surface. The small friction the wheels experience allows the applied force to dominate, so the car rolls the observed distance, demonstrating action–reaction pairs in everyday play.

Q390. A driver is distracted for 1.1 s while travelling at 28 m/s. How far does the car move during this distraction?

Solution:

Distance = speed × time = 28 m/s × 1.1 s = 30.8 m

Answer: The car covers about 31 metres—roughly seven car lengths—before the driver refocuses, highlighting how even brief distractions can lead to large unobserved gaps travelled on the road.

Q391. Describe one way to investigate the effect of music volume on student reaction time in a classroom.

Answer: Use a computer-based reaction-time program that flashes a coloured square at random intervals. Have each student perform three trials at low, medium, and high speaker volumes, keeping lighting and seating constant to control variables. Record reaction times and calculate the mean for each volume level. Compare averages using a bar chart to see if louder music consistently raises reaction times. Employ the same order for all participants or randomise volumes to reduce order effects, and ensure ethical approval by limiting sound levels to safe ranges.

Q392. Explain why snowy conditions can increase braking distance but may not affect thinking distance.

Answer: Thinking distance depends on the driver's reaction time and vehicle speed, so unless snow distracts or stresses the driver, reaction time remains unchanged. Braking distance, however, depends heavily on tyre-road friction. Snow creates a slippery layer that lowers friction dramatically, preventing tyres from gripping the road. Consequently, when brakes are applied, the wheels can lock or spin, and the car slides farther before stopping, greatly extending braking distance even though thinking distance stays the same.

Q393. A cyclist traveling downhill squeezes the brakes harder than on level ground. Explain why greater braking force is needed to stop in the same distance.
Answer: On a downhill slope, gravity adds a component of force pulling the cyclist forward, increasing the net driving force and therefore the rate at which kinetic energy builds up. To remove this extra kinetic energy over the same stopping distance, the brakes must exert a larger opposing force. Additionally, more weight shifts to the front wheel on a slope, compressing the front suspension and reducing rear-wheel grip, so the available friction must be maximised by applying stronger braking force while maintaining control.

Q394. Suggest a reason why some drivers underestimate their stopping distance at night.
Answer: Darkness narrows the visible field to the illuminated region ahead, making distant objects appear closer than they are. Streetlights and headlights can create glare or reflections that alter depth perception, so drivers misjudge how far the car will travel before stopping. Cognitive fatigue common at night also reduces the mental capacity to assess distance accurately. As a result, drivers may believe they can stop sooner than physics allows, leading to unsafe following gaps.

Q395. Explain how cruise control might influence a driver's reaction time during a long journey.
Answer: Cruise control maintains speed automatically, reducing the driver's immediate workload but also removing continuous pedal interaction that keeps them mentally engaged. Over long periods, this lower engagement can lead to monotony and lowered vigilance, potentially lengthening reaction time if a sudden hazard appears. Because the driver's foot is not already near the pedals, an extra delay may occur before braking begins. Therefore, while cruise control improves speed stability and fuel efficiency, it may slightly slow reactions unless the driver consciously remains alert.

Q396. A motorbike decelerates at 6 m/s² from 24 m/s. Calculate the stopping time under braking.
Solution:
Formula: $a = (v_f - v_i) \div t$, with $v_f = 0$
Rearranged: $t = v_i \div a = 24\ \text{m/s} \div 6\ \text{m/s}^2 = 4\ \text{s}$
Answer: The motorbike takes 4 seconds to come to rest at that deceleration rate, illustrating how strong braking is needed to stop a fast two-wheeler quickly.

Q397. In an experiment, a beep signals students to press a button. Describe how the setup could be modified to test the effect of lighting on reaction time.
Answer: Introduce adjustable lighting in the test area with three levels: bright, moderate, and dim. Keep the auditory beep stimulus but vary only the ambient illumination, ensuring all other variables remain constant. Use an automatic timer linked to the button to record reaction time accurately. Randomise the order of lighting conditions for each participant to avoid order bias, and collect several trials per level. Analyse the mean reaction times to see if poorer lighting slows responses, isolating the visual environment as the independent variable while the beep remains the constant stimulus.

Q398. Give one example where long reaction time could be beneficial rather than harmful.
Answer: In competitive archery, a slightly longer reaction time can help archers avoid flinching the

instant they release the string; by training to maintain a calm hold and accept a deliberate delay, they produce steadier shots. The extended pause allows micro-adjustments to align the sight precisely on the target centre, enhancing accuracy. So, in sports or tasks requiring precision over speed, a controlled reaction delay can improve outcomes by preventing hasty, error-prone movements.

Q399. Explain how passengers jumping off a small boat can unexpectedly move the boat backwards.
Answer: When passengers push down and backwards on the deck as they leap toward the shore, they exert a force on the boat. Newton's Third Law states the boat exerts an equal and opposite force on them, propelling the passengers forward while the boat receives a backward reaction force. Because the boat has relatively low mass and rests on low-friction water, this force causes it to accelerate noticeably in the opposite direction, making it drift away from the jetty once the passengers have left.

Q400. Outline why reducing speed limits in busy streets can greatly lower accident severity, using ideas of stopping distance.
Answer: Stopping distance rises steeply with speed because braking distance grows with the square of speed and thinking distance grows linearly. Cutting speed from 50 km/h to 30 km/h roughly halves thinking distance and cuts braking distance to less than a third, so total stopping distance drops dramatically. Shorter stopping distances give drivers more room to halt before impact and reduce collision energy if contact occurs, lowering injury severity. Lower speeds also expand a driver's field of vision, improving hazard detection and further decreasing crash likelihood.

Q401. Explain why a car needs a longer braking distance on an icy road than on a dry road.
Answer: On an icy road, the friction between the tyres and the road surface is much lower than on a dry road. Braking relies on friction to slow down and stop the vehicle. If friction is low, the braking force is reduced, and it takes longer for the vehicle to lose its kinetic energy. As a result, the car continues to travel a greater distance before coming to a stop, increasing the braking distance and the risk of losing control.

Q402. Describe how worn-out brake pads can change the distance a van takes to stop in an emergency.
Answer: Worn-out brake pads are less effective at creating the friction needed to slow the van down. With less friction between the brake pads and the wheels, the braking force is reduced. This means it takes more time and distance for the van to stop. In emergencies, this longer stopping distance can make a big difference and may result in a crash if the vehicle cannot stop in time.

Q403. Explain what happens to the kinetic energy of a car when its brakes are applied and the car stops.
Answer: When brakes are applied, the car's kinetic energy is converted into thermal energy due to the friction between the brake pads and the wheels. This frictional force slows down the car. As the car comes to a stop, all of its kinetic energy has been transferred into heat energy, which increases the temperature of the brake components. This process is how work is done to bring the car to rest.

Q404. A vehicle travelling at 30 m/s stops in 50 m. State how the braking force would have to change to stop the same vehicle in 25 m.

Answer: To stop the vehicle in half the distance, the braking force must be increased. Since the braking distance is proportional to the square of the speed for a constant force, reducing the distance by half would require doubling the braking force. This increased force is needed to remove the same amount of kinetic energy over a shorter distance, which also means the deceleration will be greater.

Q405. Explain why very large decelerations during braking can cause a driver to lose control of the vehicle.

Answer: Very large decelerations mean that the vehicle is slowing down very quickly in a short time. This can cause the tyres to lose grip with the road, especially if the surface is wet or icy. If the tyres slip, the vehicle can skid, making it hard to steer or control. This loss of control can lead to the vehicle spinning, leaving the road, or crashing into another vehicle or object, which is why smooth braking is safer.

Q406. Describe two dangers that can occur if the brakes of a lorry overheat on a long downhill road.

Answer: First, overheated brakes can become less effective due to brake fade, which means the braking force reduces even if the driver keeps pressing the brake pedal. Second, extremely high temperatures can damage the brake components, such as warping the discs or boiling the brake fluid, which can lead to complete brake failure. Both of these conditions can prevent the lorry from stopping safely, increasing crash risk.

Q407. A cyclist doubles their speed while keeping the same brakes. Explain how the required braking distance changes.

Answer: If the cyclist doubles their speed, the braking distance increases by a factor of four, because braking distance is proportional to the square of speed. This means if the original stopping distance was 5 m at 10 m/s, it becomes 20 m at 20 m/s. The same brakes have to remove four times more kinetic energy, and since they can only apply the same force, it takes much longer to stop.

Q408. A car skids when the driver brakes sharply on a wet surface. Explain why the friction force is not enough to prevent the skid.

Answer: On a wet surface, there is less friction between the tyres and the road because water creates a slippery layer. When the driver brakes suddenly, the tyres may lose grip and begin to slide. The friction force needed to slow the car down quickly is higher than what the wet surface can provide, so the tyres cannot hold the road, and the car skids, reducing control and increasing stopping distance.

Q409. A mass of 1 500 kg is moving at 20 m/s. Write an expression for its momentum and calculate the value.

Solution:

Momentum = mass × velocity = 1 500 kg × 20 m/s = 30 000 kg m/s

Answer: The momentum of the object is 30 000 kilogram metres per second. This value shows how much motion the object has, and how difficult it would be to stop it.

Q410. Explain how tyre tread depth influences the ability of a car to stop safely in heavy rain.
Answer: Tyre tread helps to channel water away from the contact area between the tyre and the road. If the tread is too shallow, water cannot escape quickly, leading to a layer of water between the tyre and the road, which causes hydroplaning. This greatly reduces grip and increases braking distance. Deeper tread maintains better contact, allowing more effective braking and safer stopping in wet conditions.

Q411. A motorcycle slows from 25 m/s to rest in 4 s. Estimate the average braking force on the motorcycle if its mass is 220 kg.
Solution:
Deceleration = change in velocity / time = 25 m/s ÷ 4 s = 6.25 m/s^2
Force = mass × deceleration = 220 kg × 6.25 m/s^2 = 1 375 N
Answer: The average braking force acting on the motorcycle is 1 375 newtons, which shows the amount of force needed to stop it within the given time.

Q412. State why the temperature of disc brakes rises after repeated hard braking on a race track.
Answer: Each time the brakes are used, they convert kinetic energy into thermal energy through friction. On a race track, repeated hard braking happens over short intervals, which means the brakes do not have time to cool down between uses. This causes heat to build up with each braking event, raising the temperature of the brake discs significantly. If the heat is not managed, it can lead to brake fade or damage.

Q413. Give one reason why anti-lock braking systems can help reduce the dangers of large decelerations.
Answer: Anti-lock braking systems (ABS) prevent the wheels from locking up when the brakes are applied suddenly. This allows the driver to maintain steering control while braking, reducing the chance of skidding or sliding. By avoiding wheel lock, ABS ensures that braking force is applied more evenly and safely, even during large decelerations, which helps avoid accidents and keeps the vehicle more stable.

Q414. A van and a small car travel at the same speed. Use the idea of work done by friction to explain why the van may need a larger braking force to stop in the same distance.
Answer: Work done to stop a vehicle equals the energy it has, which is its kinetic energy. Since the van has more mass than the car, it has more kinetic energy at the same speed. To stop in the same distance, the brakes of the van must do more work. This means the braking force must be larger to remove more energy over the same distance, so the van needs stronger brakes or more braking effort.

Q415. A bus driver claims that halving the speed will quarter the braking distance on the same road. Explain whether this claim is reasonable.
Answer: This claim is correct. Braking distance is proportional to the square of the speed. So, if the speed is halved, the braking distance becomes one-quarter of the original. For example, if a bus needs 40 m to stop from 20 m/s, it will need only 10 m to stop from 10 m/s, assuming the road and

brakes are the same. This is because kinetic energy depends on speed squared and braking force remains constant.

Q416. A car of mass 1 200 kg experiences a braking force of 4 800 N. Calculate its deceleration.
Solution:
Deceleration = force ÷ mass = 4 800 N ÷ 1 200 kg = 4 m/s^2
Answer: The car decelerates at a rate of 4 metres per second squared, which shows how quickly its speed is reduced under that braking force.

Q417. Describe how icy road conditions can affect both the braking force available and the risk of losing control.
Answer: Icy roads provide very little friction between the tyres and the road surface. This reduces the braking force that can be applied before the tyres start to slide. If the driver brakes hard, the tyres can lock and skid, causing a loss of control. Steering becomes ineffective during a skid, and the vehicle may not stop in time, increasing the chance of collisions, especially if other vehicles are nearby.

Q418. Explain why momentum is always zero for an object at rest, even if it has a large mass.
Answer: Momentum is calculated by multiplying mass by velocity. An object at rest has zero velocity, so its momentum is zero regardless of how large its mass is. For example, a parked truck may have great mass, but since it is not moving, it has no momentum. Momentum only exists when an object is moving, because velocity is required to give the object any momentum.

Q419. A 900 kg car travelling at 15 m/s collides with a stationary barrier and stops in 0.3 s. Estimate the average force exerted on the car.
Solution:
Momentum = mass × velocity = 900 kg × 15 m/s = 13 500 kg m/s
Force = change in momentum ÷ time = 13 500 kg m/s ÷ 0.3 s = 45 000 N
Answer: The average force exerted on the car during the collision is 45 000 newtons. This shows the large force needed to stop a moving vehicle in a very short time.

Q420. Explain the link between kinetic energy removed during braking and the risk of brake fade on a steep mountain pass.
Answer: On a steep slope, a vehicle's brakes must work constantly to remove the extra kinetic energy gained due to gravity pulling it downhill. The longer the descent, the more braking is needed, and more kinetic energy is converted into heat. This continuous heating can cause brake components to get too hot, reducing their ability to produce friction. This is called brake fade, and it increases the stopping distance and risk of losing control.

Q421. A driver notices a vibration when braking hard. Give two possible reasons related to the brake condition.
Answer: First, the brake discs may be warped due to uneven heating, causing the brake pads to make inconsistent contact with the disc surface. Second, the brake pads may be worn unevenly, so

they do not press flatly against the discs, creating vibrations. Both problems reduce braking effectiveness and can lead to longer stopping distances or damage to the braking system.

Q422. A lorry's tyres are under-inflated. Explain how this could change its stopping distance in an emergency.

Answer: Under-inflated tyres have a larger contact area with the road, which can reduce the tyre's ability to grip properly. This increases rolling resistance but may also lead to poor water dispersion and reduced braking efficiency. As a result, the tyres might not respond well under sudden braking, especially on wet roads, increasing the braking distance and the risk of skidding or tyre damage.

Q423. State the equation that links momentum, mass and velocity, and explain how it can be used to compare two vehicles travelling at the same speed.

Answer: The equation is momentum = mass × velocity ($p = m \times v$). If two vehicles are moving at the same speed, the one with greater mass will have more momentum. This means it will be harder to stop and will require more braking force. For example, a lorry has much more mass than a car, so at the same speed, it has greater momentum and needs more distance or stronger brakes to stop.

Q424. Explain why the braking distance increases more quickly than thinking distance as speed rises.

Answer: Thinking distance increases in direct proportion to speed because the driver's reaction time stays roughly constant, so more speed means more distance travelled in that time. Braking distance increases with the square of the speed because the kinetic energy that needs to be removed increases with speed squared. So, a small increase in speed causes a large increase in braking distance, making it a bigger risk.

Q425. Describe the safety implications of underestimating the forces involved when planning stopping zones on a public road.

Answer: If stopping zones are too short, vehicles travelling at normal speeds may not be able to stop in time to avoid obstacles or hazards, especially in wet or icy conditions. Underestimating the forces involved in braking means the deceleration required may exceed what the tyres and brakes can safely provide. This can cause skidding, crashes, or rollovers, putting both drivers and pedestrians at risk. Properly designed stopping zones allow safe deceleration using available friction.

Q426. Two trolleys collide on a smooth surface and stick together. Explain how the law of conservation of momentum applies to this collision.

Answer: The law of conservation of momentum states that the total momentum before a collision is equal to the total momentum after the collision, provided no external forces act. When the two trolleys collide and stick together, their combined mass moves with a common velocity. The momentum before the collision, calculated from both trolleys' masses and velocities, will be equal to the total momentum of the joined trolleys after the collision.

Q427. A 5 kg trolley moving at 2 m/s collides with a stationary 3 kg trolley. After the collision, the trolleys stick together. Calculate their velocity after the collision.

Solution:

Initial momentum = (5 kg × 2 m/s) + (3 kg × 0 m/s) = 10 kg m/s

Total mass after collision = 5 kg + 3 kg = 8 kg

Final velocity = total momentum ÷ total mass = 10 kg m/s ÷ 8 kg = 1.25 m/s

Answer: The trolleys move together at a velocity of 1.25 m/s after the collision.

Q428. Describe what is meant by the conservation of momentum in your own words and give an example.

Answer: Conservation of momentum means that the total momentum in a closed system does not change before and after an event like a collision, as long as there are no external forces. For example, if two ice skaters push off each other, one moves in one direction and the other in the opposite direction. Their total momentum stays the same, just distributed between them.

Q429. A car crashes into a wall and comes to rest. Use the idea of change in momentum to explain how an airbag reduces injury.

Answer: In a crash, the car and the person inside quickly lose all their momentum as they come to rest. An airbag increases the time over which the person's momentum changes. This longer time reduces the force experienced, because force equals change in momentum divided by time. Lower force means less chance of serious injury.

Q430. A footballer kicks a stationary ball of mass 0.5 kg and gives it a velocity of 20 m/s. Calculate the change in momentum of the ball.

Solution:

Initial momentum = 0

Final momentum = 0.5 kg × 20 m/s = 10 kg m/s

Change in momentum = final − initial = 10 kg m/s − 0 = 10 kg m/s

Answer: The ball's change in momentum is 10 kilogram metres per second.

Q431. Two ice skaters push off each other and move in opposite directions. Explain how their movements show conservation of momentum.

Answer: Before pushing off, both skaters are stationary, so their total momentum is zero. When they push off, one moves in one direction and the other in the opposite direction. The momentum gained by one is equal in size but opposite in direction to the momentum gained by the other, so the total momentum still adds up to zero, showing conservation of momentum.

Q432. A car of mass 1 000 kg slows from 25 m/s to 5 m/s in 4 seconds. Calculate the average braking force acting on the car.

Solution:

Change in velocity = 25 − 5 = 20 m/s

Change in momentum = 1 000 kg × 20 m/s = 20 000 kg m/s

Force = change in momentum ÷ time = 20 000 kg m/s ÷ 4 s = 5 000 N

Answer: The average braking force is 5 000 newtons.

Q433. Describe an experiment using light gates to investigate the conservation of momentum during a collision between two trolleys.
Answer: Place two trolleys on a smooth track with light gates positioned to measure their speeds before and after collision. Push one trolley towards the other and let them collide. Use a data logger connected to the light gates to record velocities. Measure the mass of each trolley. Calculate momentum before and after the collision using mass × velocity. Compare total momentum before and after to check if it is conserved.

Q434. Explain how cycle helmets reduce head injuries using the idea of rate of change of momentum.
Answer: A cycle helmet spreads out the force of impact and increases the time over which the cyclist's head slows down during a crash. This reduces the rate of change of momentum and, according to the formula force = change in momentum ÷ time, results in a smaller force on the head. Less force means a lower risk of serious injury.

Q435. A lorry of mass 3 000 kg travelling at 10 m/s collides with a stationary car of mass 1 200 kg. Calculate the total momentum before the collision.
Solution:
Lorry momentum = 3 000 kg × 10 m/s = 30 000 kg m/s
Car momentum = 0 kg m/s
Total momentum = 30 000 kg m/s + 0 = 30 000 kg m/s
Answer: The total momentum before the collision is 30 000 kilogram metres per second.

Q436. A cricket ball is hit back in the opposite direction with greater speed than it was bowled. Explain the change in momentum of the ball.
Answer: The ball's momentum changes direction and increases in size. If it was moving towards the batter, then after being hit it moves away at a higher speed. This means the change in momentum is large and in the opposite direction. The force needed to cause this change in momentum is large and applied over a short time, which is why the bat must apply a strong force quickly.

Q437. Describe how cushioned surfaces in playgrounds reduce the risk of injury in terms of force and time.
Answer: Cushioned surfaces increase the time over which a child's body comes to rest after a fall. Since force equals change in momentum divided by time, increasing the time reduces the force on the body. Lower forces reduce the chance of injury, which is why soft flooring is used under swings and slides in playgrounds.

Q438. A ball bounces off a wall with no loss in speed but in the opposite direction. Describe the change in its momentum.
Answer: The ball's momentum before the bounce is in one direction, and after the bounce it has the same speed but opposite direction. Since momentum is a vector, this means the direction is important. The change in momentum is equal to the final momentum minus the initial momentum, which results in a large change due to the reversal in direction.

Q439. A driver wearing a seatbelt is involved in a crash. Explain how the seatbelt helps to reduce the force on the driver.

Answer: In a crash, the driver's body would continue moving forward unless stopped. A seatbelt stretches slightly, which increases the time it takes to stop the driver. By increasing the stopping time, the seatbelt reduces the rate of change of momentum. This results in a smaller force on the driver's body, reducing the chance of injury.

Q440. A 60 kg person jumps off a boat and moves at 2 m/s. Explain why the boat moves in the opposite direction.

Answer: Before jumping, the total momentum of the person and boat is zero. When the person jumps forward, they gain forward momentum. To conserve momentum, the boat must gain an equal amount of momentum in the opposite direction. Since the boat has more mass, its velocity is smaller, but the product of mass and velocity balances that of the person.

Q441. A rocket in space expels gas backwards. Use conservation of momentum to explain how this makes the rocket move forwards.

Answer: Initially, both the rocket and gas are stationary, so total momentum is zero. When gas is expelled backwards, it gains momentum in that direction. To conserve momentum, the rocket must gain an equal momentum in the opposite direction. This causes the rocket to move forward. The total momentum remains zero, but is shared between the rocket and the gas.

Q442. A 2 kg trolley moving at 3 m/s hits another 2 kg trolley moving at 1 m/s in the same direction. If they stick together, calculate their velocity after the collision.

Solution:

Initial momentum = (2 kg × 3 m/s) + (2 kg × 1 m/s) = 6 kg m/s + 2 kg m/s = 8 kg m/s

Total mass = 4 kg

Final velocity = total momentum ÷ total mass = 8 kg m/s ÷ 4 kg = 2 m/s

Answer: The trolleys move together at a velocity of 2 m/s after the collision.

Q443. A gymnast lands on a crash mat. Explain why landing on a mat causes less injury than landing on a hard floor.

Answer: The crash mat compresses when the gymnast lands, increasing the time over which the gymnast's momentum changes. This reduces the force needed to stop the gymnast, as force = change in momentum ÷ time. The softer the mat, the longer the time and the lower the force, which lowers the risk of injury compared to landing on a hard surface.

Q444. Explain how momentum changes when a bullet is fired from a gun and how this leads to recoil.

Answer: Before the bullet is fired, the total momentum of the bullet and gun is zero. When the bullet is fired forward, it gains forward momentum. To conserve momentum, the gun gains an equal amount of momentum in the opposite direction, which is recoil. Although the gun's mass is much larger, the velocity is smaller, so both momenta are equal in size and opposite in direction.

Q445. A force of 500 N acts on a 50 kg object for 2 s. Calculate the change in momentum.
Solution:
Change in momentum = force × time = 500 N × 2 s = 1 000 kg m/s
Answer: The object's momentum changes by 1 000 kilogram metres per second.

Q446. Describe the relationship between force and the rate of change of momentum.
Answer: Force is equal to the rate of change of momentum. This means that the bigger the change in momentum or the shorter the time over which the change happens, the larger the force. This relationship is written as force = change in momentum ÷ time. It shows that for the same momentum change, increasing the time reduces the force.

Q447. A motorbike of mass 150 kg increases its velocity from 8 m/s to 20 m/s in 4 s. Calculate the average resultant force acting on it.
Solution:
Change in momentum = 150 kg × (20 m/s − 8 m/s) = 150 × 12 = 1 800 kg m/s
Force = change in momentum ÷ time = 1 800 kg m/s ÷ 4 s = 450 N
Answer: The average force acting on the motorbike is 450 newtons.

Q448. Explain how the time taken to stop a moving object affects the size of the force experienced by it.
Answer: When an object is stopped, the momentum must change. If this happens in a short time, the force must be large. If the time is longer, the force can be smaller. This is because force = change in momentum ÷ time. So increasing the stopping time reduces the force, which is why soft surfaces or safety features help prevent injuries by increasing the time it takes to stop.

Q449. Two identical trolleys are pushed towards each other with equal speed and collide head-on. Describe what happens to their motion after the collision.
Answer: Since the trolleys have the same mass and speed but opposite velocities, their total momentum before the collision is zero. If they stick together after the collision, they remain at rest. If they bounce apart with the same speed in opposite directions, the momentum is still conserved and total momentum remains zero.

Q450. Explain why gymnasts perform landings with bent knees in terms of momentum and force.
Answer: Bending the knees during landing increases the time over which the gymnast's momentum is reduced to zero. Since force = change in momentum ÷ time, increasing the time reduces the force on the legs and joints. This helps protect the gymnast from injuries by reducing the impact of landing.

Q451. Define velocity and explain how it differs from speed.
Answer: Velocity is a measure of how fast an object is moving and in which direction it is moving. It is defined as the rate of change of displacement with respect to time and is therefore a vector quantity, meaning it has both magnitude and direction. Speed, in contrast, is the rate of change of distance with respect to time and is a scalar quantity, meaning it has only magnitude and no specific direction. Two cars travelling at 20 m/s can have the same speed, but if one goes east and the other

west, their velocities are different because their directions differ. Because velocity includes direction, it can change even when speed remains constant, such as when a car moves around a roundabout at steady speed but constantly changes direction. Understanding the difference is important in physics because many laws, like the conservation of momentum, depend on vector quantities, not just their magnitudes.

Q452. Give two examples of scalar quantities and two examples of vector quantities in physics.
Answer: Scalar quantities, which have magnitude only, include temperature and mass. Temperature tells how hot or cold something is but does not point in any direction; mass tells how much matter is in an object and, again, has no direction. Vector quantities, which have both magnitude and direction, include force and displacement. A force of 10 N to the right is very different from 10 N to the left because reversing direction reverses the vector. Displacement likewise relies on the straight-line distance and the specific direction from the start point to the end point. Many other familiar vectors are velocity and acceleration; many other scalars are energy and time. Distinguishing between scalars and vectors allows us to add quantities correctly: vector addition uses both size and direction, while scalars simply add algebraically.

Q453. A car travels 100 m north and then 100 m south. What is its total displacement?
Solution:
Total displacement = final position – initial position.
Net northwards distance = 100 m – 100 m = 0 m.
Answer: The total displacement is zero because the car ends up back where it started even though it has travelled a total distance of 200 m. Displacement cares only about where the object is compared with the starting point, not the path taken, so the outward and return journeys cancel each other exactly in opposite directions, leaving no overall change in position.

Q454. A runner completes a circular track of 400 m in 60 seconds. Explain why the velocity is not constant.
Answer: Although the runner's speed (400 m divided by 60 s, about 6.7 m/s) may remain nearly steady, velocity is a vector that depends on direction as well as speed. While running around a circle, the direction of motion changes continuously at every point along the curve. Each tiny segment of the path has its own tangent direction, so the velocity vector is always rotating. Because velocity changes whenever its direction changes, even at constant speed, the runner's velocity is never constant; it varies steadily around the track, demonstrating that uniform circular motion involves continual acceleration toward the centre of the circle, known as centripetal acceleration, even when speed stays uniform.

Q455. What does the gradient of a distance–time graph represent?
Answer: The gradient, or slope, of a distance–time graph gives the speed of the object. Mathematically, gradient equals the vertical change (distance travelled) divided by the horizontal change (time taken), which is exactly the definition of speed. If the graph is a straight line, the gradient is constant and the object moves at constant speed. If the gradient increases or decreases, it shows that the object is speeding up or slowing down respectively. The gradient's sign tells the

direction along the chosen axis: a positive slope indicates motion in the positive direction of the axis, while a horizontal section (zero gradient) shows the object is stationary during that time interval.

Q456. A student walks 300 m in 150 seconds. Calculate their average speed.
Solution:
Speed = distance ÷ time = 300 m ÷ 150 s = 2 m/s.
Answer: The student's average speed is 2 metres per second. Average speed is calculated by dividing total distance travelled by total time taken, regardless of any short stops or variations in pace during the journey. Because the calculation uses total values, it does not reveal whether the student moved faster or slower at different moments, only the overall pace over the complete walk.

Q457. A car moves in a circle at a constant speed. Explain why its velocity is changing.
Answer: Velocity is defined by both speed and direction. Even if the car's speed remains constant, as it travels around the circular path the direction of its motion is always changing. Each new point on the circle has a different tangent direction, so the car's velocity vector rotates continuously. Because a change in direction is a change in velocity, the car experiences an acceleration toward the centre of the circle called centripetal acceleration. This means that although the magnitude of velocity (the speed) is constant, the vector itself is not, so velocity is changing all the time as the car moves around the circle.

Q458. Describe how to use a tangent to find the speed of an accelerating object from a distance–time graph.
Answer: On a curved distance–time graph, which indicates changing speed, select the specific time at which you want to know the speed. Draw a tangent line that just touches the curve at that point without cutting through it nearby—this line represents the instantaneous direction of the curve. Choose two convenient points on this tangent well apart to reduce measurement error, record their coordinates (distance and time), and calculate the gradient using rise over run. That gradient gives the instantaneous speed at that exact moment because it represents the distance change per unit time that the object would have if it kept moving as the tangent predicts. By repeating at different times, you can map how speed varies during the motion.

Q459. Sketch a distance–time graph for an object at rest and describe its features.
Answer: For an object at rest, distance does not change as time passes, so the graph is a horizontal line parallel to the time axis. Its height (the distance value) equals the fixed distance from the origin where the object remains—for instance, at zero if it has not moved from the start. The line's gradient is zero, showing zero speed. No matter how far along the time axis you move, the distance reading stays constant, graphically confirming the object's stationary state.

Q460. Sketch a distance–time graph for an object moving at a constant speed and explain the shape.
Answer: A constant, non-zero speed produces a straight line sloping upward from left to right on a distance–time graph. The line originates at the starting point—often the graph origin—and its constant gradient equals the object's speed. The steeper the line, the greater the speed. Straightness means

distance increases uniformly with time; there is no curvature because the object covers equal distances in equal intervals, indicating no acceleration.

Q461. Sketch a distance–time graph for an object that is speeding up and explain the shape.
Answer: When an object accelerates, the distance it covers in each equal time interval grows, so the distance–time graph curves upward, becoming steeper with time. Starting gently, the slope increases, indicating increasing speed. Mathematically, the graph's gradient, which shows speed, rises as time advances. This concave-upward curve (resembling the right half of a parabola) visually represents increasing velocity, and a tangent drawn later in time would have a greater gradient than one drawn earlier.

Q462. What is the difference between distance and displacement?
Answer: Distance is the total length of the path travelled by an object, regardless of direction; it is always non-negative and is a scalar quantity. Displacement, on the other hand, is the straight-line vector from the starting point to the ending point, including direction. It can be positive, negative, or zero depending on the chosen coordinate system. If a hiker walks 5 km north and then 5 km south, the distance covered is 10 km, but the displacement is zero because the hiker returns to the starting point. Displacement is crucial in physics equations that rely on vectors, such as those involving velocity and acceleration.

Q463. A car travels 600 m in 60 seconds. Then it stops for 30 seconds. Sketch a distance–time graph for this journey.
Answer: The graph starts at the origin. For the first 60 s, draw a straight line from (0,0) to (60 s, 600 m). This line's gradient shows a constant speed of 10 m/s. From 60 s to 90 s, draw a horizontal line at 600 m because the distance does not change while the car is stationary. The graph clearly displays motion followed by rest: an upward sloping segment then a flat segment.

Q464. Explain how to determine the speed of an object from a curved distance–time graph.
Answer: Select the time of interest and draw a tangent at that point on the curve so that it just touches without crossing the curve. Mark two points on the tangent that are far apart for accuracy and read their distance and time coordinates. Calculate the difference in distance (rise) and in time (run) between these two points and divide rise by run to get the gradient. This gradient represents the instantaneous speed at that specific moment because on a distance–time graph the gradient equals speed. Repeating this at multiple points gives a full speed profile.

Q465. An object moves along a straight road and comes to rest. How is this shown on a distance–time graph?
Answer: Initially the graph shows an upward sloping line whose gradient represents the object's speed along the road. As the object decelerates, the slope may curve, decreasing toward horizontal. When the object is fully at rest, the line becomes horizontal because distance no longer changes with time. The point where the line turns flat marks the moment the object stopped, and the subsequent flat section shows the stationary period.

Q466. A cyclist travels 4 km north, then 3 km east. Explain how to calculate their displacement.
Solution:
Treat the journey as a right-angled triangle with legs 4 km and 3 km.
Displacement = $\sqrt{(4^2 + 3^2)}$ km = $\sqrt{(16 + 9)}$ = $\sqrt{25}$ = 5 km.
Direction = arctan(3/4) ≈ 37° east of north.
Answer: The cyclist's displacement is 5 kilometres at about 37 degrees east of north. Distance covered is 7 km, but displacement reflects only the straight-line separation between start and finish, found using Pythagoras' theorem because the north and east legs form a right angle.

Q467. A distance–time graph has a steep straight line. What does this indicate about the object's speed?
Answer: A steeper line means a greater gradient, which on a distance–time graph translates to a higher speed. The object covers a large distance in a short time interval. If the line is straight, the speed is constant. Comparing two straight segments, the steeper one corresponds to the faster section of the journey. Thus, a steep straight line signals rapid, steady motion.

Q468. A line on a distance–time graph curves upwards. What does this tell you about the object's motion?
Answer: An upward-curving line indicates that the gradient—and therefore the speed—is increasing with time. The object is accelerating, covering more distance in each successive time interval. The curve's steepness reveals how quickly the speed is increasing: a sharply rising curve shows strong acceleration, while a gentle curve shows mild acceleration. The lack of straightness means the speed is not constant.

Q469. How can you tell from a distance–time graph that an object is moving at constant speed?
Answer: If the graph shows a straight line whose slope does not change over time, the gradient is constant. Because the gradient equals speed on a distance–time graph, a constant gradient means constant speed. Straightness, not steepness, signals unchanging speed; the steeper the straight line, the faster the constant speed, while the shallower the straight line, the slower.

Q470. Describe a method to draw a distance–time graph from experimental data.
Answer: First collect paired distance and time readings, ensuring accurate measurement tools such as motion sensors or stopwatches and metre rules. Record the data in a table, listing time in one column and corresponding distance in another. Choose suitable scales so the full range fits on graph paper with axes labelled properly and units included. Plot each data point as a small, neat dot. If motion is expected to be smooth, join the points with a thin line or curve that best fits the overall trend rather than segmenting with straight lines between every pair. Finally, check the shape: straight for constant speed or curved for acceleration. The completed graph visually represents the motion and allows gradients to be assessed for speed calculation.

Q471. Explain why speed is a scalar quantity but velocity is a vector quantity.
Answer: Speed is a scalar quantity because it only tells us how fast an object is moving, without considering the direction. It has only magnitude. On the other hand, velocity is a vector quantity

because it includes both the speed and the direction of motion. For example, 10 m/s is speed, but 10 m/s east is velocity. So, velocity gives more information as it describes the direction along with the speed.

Q472. A student walks 1.2 km in 15 minutes. What is their average speed in m/s?
Answer: The average speed is 1.33 m/s.
Solution:
Convert distance to metres: 1.2 km = 1200 m
Convert time to seconds: 15 min = 15 × 60 = 900 s
Use the formula:
Speed = Distance ÷ Time
Speed = 1200 ÷ 900 = 1.33 m/s

Q473. A bus accelerates along a straight road. How would this appear on a distance–time graph?
Answer: On a distance–time graph, acceleration appears as a curve that gets steeper with time. As the bus speeds up, it covers more distance in less time, so the graph curves upwards, showing increasing gradient which represents increasing speed.

Q474. A ball rolls down a hill and speeds up. How would its distance–time graph change?
Answer: The graph would be a curve that becomes steeper as time goes on. This is because the ball is accelerating, and as it picks up speed, the distance it travels in each second increases, which causes the graph to bend upwards more sharply.

Q475. What information is needed to calculate speed from a distance–time graph?
Answer: To calculate speed from a distance–time graph, you need the change in distance and the change in time between two points on the graph. By finding the gradient (slope) of the graph between two points, you can determine the speed, since speed = distance ÷ time.

Q476. A person jogs 500 m east and 500 m west. What is the displacement and total distance travelled?
Answer: The total distance travelled is 1000 m. The displacement is 0 m.
Explanation: Displacement is the straight-line distance from the starting point to the ending point. Since the person returns to the starting point after jogging east and then west, the overall change in position is zero. However, the distance they covered is the sum of both parts: 500 + 500 = 1000 m.

Q477. Explain how a curved distance–time graph shows acceleration.
Answer: A curved distance–time graph shows acceleration because the object's speed is changing. If the curve gets steeper over time, it means the object is speeding up. If it becomes less steep, it means the object is slowing down. The changing gradient of the curve indicates that the speed is not constant, which is a sign of acceleration or deceleration.

Q478. A vehicle's distance–time graph has a horizontal line. What does this mean?
Answer: A horizontal line on a distance–time graph means the vehicle is stationary. This is because

the distance is not changing over time. No movement is taking place, so the object remains at the same position during that period.

Q479. How do you convert a distance–time graph into a speed–time graph?
Answer: To convert a distance–time graph into a speed–time graph, you calculate the gradient (slope) of the distance–time graph at various points. The gradient represents speed. For straight sections, the gradient is constant, so the speed is constant. For curved sections, find the gradient at different points to get the changing speed and plot those values on the speed–time graph.

Q480. A train travels at a steady speed for 10 minutes. Describe how its distance–time graph would look.
Answer: The distance–time graph would be a straight line with a constant upward slope. This means the train is covering equal distances in equal time intervals, indicating that the speed is steady and not changing throughout the 10 minutes.

Q481. A runner's distance–time graph is a curve getting steeper. What does this mean?
Answer: A curve getting steeper on a distance–time graph means the runner is accelerating. The steeper the graph, the faster the runner is moving. Since the steepness increases with time, it shows that the runner's speed is increasing as time goes on.

Q482. A swimmer swims 100 m in 80 seconds. What is their average speed?
Answer: The average speed is 1.25 m/s.
Solution:
Use the formula: Speed = Distance ÷ Time
Speed = 100 ÷ 80 = 1.25 m/s

Q483. Describe how to measure the gradient of a straight line on a graph.
Answer: To measure the gradient of a straight line, pick two points on the line. Find the difference in distance (vertical axis) and divide it by the difference in time (horizontal axis). Gradient = change in distance ÷ change in time. This value represents the speed when using a distance–time graph.

Q484. How do you use a distance–time graph to identify when an object is stationary?
Answer: On a distance–time graph, an object is stationary when the line is horizontal. This means that the distance from the starting point is not changing over time, showing that the object is not moving during that time period.

Q485. A runner covers 100 m in 12.5 seconds. Sketch a distance–time graph for this run.
Answer: The graph would be a straight line starting at (0,0) and ending at (12.5, 100). The line would have a constant slope since the runner is moving at a steady speed. The slope or gradient of the line represents the speed, which in this case is 100 ÷ 12.5 = 8 m/s.

Q486. What is the SI unit of velocity and how is it expressed?
Answer: The SI unit of velocity is metres per second (m/s). It is expressed as the distance an object travels in a specific direction per unit of time. Since velocity includes both speed and direction, the unit stays the same as speed, but direction is often added in description, such as 10 m/s north.

Q487. A car moves 2 km north, then 2 km south in 10 minutes. What is the displacement?
Answer: The displacement is 0 km.
Explanation: Displacement is the straight-line distance from the starting point to the ending point. Since the car returns to its original position after moving 2 km north and then 2 km south, there is no overall change in position, so the displacement is zero.

Q488. A distance–time graph shows a changing gradient. What does this mean?
Answer: A changing gradient on a distance–time graph means that the speed of the object is changing. If the slope increases, the object is speeding up (accelerating). If the slope decreases, the object is slowing down (decelerating). This shows that the motion is not uniform.

Q489. Why is it important to label axes correctly on a distance–time graph?
Answer: Labeling axes correctly is important to understand what the graph is showing. On a distance–time graph, the vertical axis must be distance and the horizontal axis must be time. Without clear labels, it would be confusing to interpret the motion of the object, and any calculations or analysis would be incorrect.

Q490. Describe one real-world example where an object travels at constant speed but changing velocity.
Answer: A car moving at a constant speed around a circular track is a good example. Even though the speed remains the same, the direction is constantly changing as it turns, so the velocity is changing. This is because velocity is a vector and depends on both speed and direction.

Q491. How would you calculate instantaneous speed from a curved distance–time graph?
Answer: To find instantaneous speed from a curved distance–time graph, you draw a tangent line at the point of interest on the curve. Then measure the gradient (slope) of that tangent. The gradient represents the instantaneous speed at that moment, as it shows how fast the object is moving at that specific time.

Q492. What is the key difference between average speed and instantaneous speed?
Answer: Average speed is calculated over a period of time and is found by dividing total distance by total time. Instantaneous speed is the speed of an object at a specific moment. While average speed gives an overall idea of motion, instantaneous speed tells us how fast the object is moving at one exact point in time.

Q493. A cyclist moves at 5 m/s for 120 seconds. How far does the cyclist travel?
Answer: The cyclist travels 600 metres.
Solution:
Use the formula: Distance = Speed × Time
Distance = 5 × 120 = 600 m

Q494. Explain how displacement can be zero even when distance travelled is not.
Answer: Displacement is the straight-line distance from the starting point to the final point. If an object moves away from its starting point and then returns, the displacement is zero because there's

no net change in position. However, the distance travelled includes the entire path, which may be more than zero.

Q495. Describe how you would plot a distance–time graph using data from a motion sensor.
Answer: First, collect data from the motion sensor, which gives distance readings at regular time intervals. Then, on graph paper or software, plot time on the horizontal axis and distance on the vertical axis. Plot each data point and connect them. The shape of the graph will show whether the object was moving at constant speed, accelerating, or stationary.

Q496. How does motion in a circle show the link between speed, velocity, and acceleration?
Answer: In circular motion, even if speed is constant, velocity is changing due to the change in direction. This continuous change in direction means there is acceleration towards the centre of the circle, known as centripetal acceleration. So, circular motion shows that even constant speed can involve changing velocity and continuous acceleration.

Q497. A student plots a distance–time graph with wobbly curves. What does this suggest about their motion?
Answer: Wobbly curves on a distance–time graph suggest that the student's speed is changing irregularly. It could mean the student is speeding up and slowing down in an unpredictable way. The motion is not smooth or steady, showing variations in how fast or slow the object was moving.

Q498. Describe how the direction of travel affects velocity but not speed.
Answer: Speed is only concerned with how fast an object moves, so it doesn't change if direction changes. Velocity, on the other hand, includes direction. So, if an object turns around or changes its path while maintaining the same speed, the speed stays the same but the velocity changes because the direction has changed.

Q499. What graph shape would you expect from a car that speeds up and then slows down?
Answer: The distance–time graph would show a curve that first gets steeper (indicating acceleration) and then becomes less steep (indicating deceleration). It would look like a hill shape—steep rise followed by a gentle flattening—showing the change in speed over time.

Q500. Compare the motion shown by two different distance–time graphs: one with a constant gradient, and one with a curved line.
Answer: A graph with a constant gradient shows motion at a steady speed, meaning the object is moving the same distance every second. A curved line shows changing speed—if the curve gets steeper, the object is accelerating; if it flattens, the object is slowing down. So, one shows uniform motion, and the other shows non-uniform motion.

Q501. A car accelerates from rest to 25 m/s in 8 s; using the average-acceleration equation, calculate its acceleration and give the correct SI units.
Answer: The acceleration is 3.125 m/s².
Solution:
Initial velocity, u = 0 m/s

Final velocity, v = 25 m/s
Time taken, t = 8 s
Use the formula: $a = (v - u) / t$
$a = (25 - 0) / 8 = 25 / 8 = 3.125$ m/s²

Q502. A cyclist slows from 12 m/s to 4 m/s in 3 s; show that this is a deceleration and work out its value.
Answer: The cyclist is decelerating at 2.67 m/s².
Solution:
Initial velocity, u = 12 m/s
Final velocity, v = 4 m/s
Time taken, t = 3 s
$a = (v - u) / t = (4 - 12) / 3 = -8 / 3 = -2.67$ m/s²
The negative sign shows deceleration.

Q503. Give one everyday situation where a typical acceleration is about 3 m/s² and explain clearly how you would estimate that figure.
Answer: A car pulling away from a traffic light can have an acceleration around 3 m/s². To estimate this, observe the time it takes to reach 30 m/s (about 108 km/h). If the car takes around 10 s to do this, using the formula $a = \Delta v / t = 30 / 10 = 3$ m/s², we get a good approximation of the car's acceleration.

Q504. Describe step by step how you would draw a velocity–time graph from a set of velocity readings taken every second during a trolley experiment.
Answer: Start by drawing axes with time on the x-axis and velocity on the y-axis. Mark the time intervals equally, such as every second. Then, for each reading, place a point at the matching velocity value. After plotting all points, connect them with straight or curved lines depending on how the velocity changes. The shape of the graph will show acceleration, constant speed, or deceleration.

Q505. A velocity–time graph for a motorbike is a straight line rising from 0 to 30 m/s in 6 s; explain how its gradient shows the bike's acceleration.
Answer: The gradient of a velocity–time graph represents acceleration. A straight line rising from 0 to 30 m/s in 6 s shows constant acceleration. The gradient is calculated as change in velocity ÷ time = $(30 - 0) / 6 = 5$ m/s². This means the bike is accelerating steadily at 5 m/s².

Q506. For the graph in Q505, calculate the distance travelled in those 6 s by finding the area under the line.
Answer: The distance is 90 metres.
Solution:
The graph forms a triangle with base = 6 s and height = 30 m/s
Area = ½ × base × height = ½ × 6 × 30 = 90 m

Q507. An athlete runs with uniform acceleration from 4 m/s to 10 m/s over a distance of 48 m; use $v^2 - u^2 = 2as$ to find the acceleration and the time taken.

Answer: The acceleration is 0.875 m/s² and the time is about 6.86 s.
Solution:
$v^2 - u^2 = 2as \rightarrow 10^2 - 4^2 = 2 \times a \times 48$
$100 - 16 = 96a \rightarrow 84 = 96a$
$a = 84 / 96 = 0.875\ m/s^2$
Now use $v = u + at \rightarrow t = (v - u)/a = (10 - 4) / 0.875 = 6 / 0.875 \approx 6.86\ s$

Q508. Explain why an object falling freely near Earth's surface has an acceleration close to 9.8 m/s² and discuss two factors that might cause small variations in this value.
Answer: The acceleration due to gravity is about 9.8 m/s² near Earth because of Earth's mass and radius. Small variations can occur due to altitude (gravity is slightly less at higher altitudes) and local geology (dense rocks below Earth's surface may increase gravitational pull slightly). These differences are minor but can be measured with sensitive equipment.

Q509. A stone is dropped from a cliff and reaches terminal velocity after 4 s; sketch and describe the main features of its velocity–time graph, marking where acceleration becomes zero.
Answer: The graph starts with a straight upward slope showing acceleration at 9.8 m/s², then gradually curves until it flattens out. The flat section shows constant velocity, which is terminal velocity. The point where the line becomes horizontal is where the acceleration becomes zero because the forces are balanced.

Q510. Describe the sequence of vertical forces acting on a skydiver from leaving the aircraft to reaching terminal velocity with an open parachute.
Answer: When the skydiver jumps, gravity pulls them down and acceleration increases. As they fall faster, air resistance builds. When air resistance equals the weight, the net force is zero, and terminal velocity is reached. After opening the parachute, air resistance suddenly increases, causing deceleration until a new lower terminal velocity is reached.

Q511. Outline a practical method, using a motion sensor, to measure the effect of air resistance on a model parachute and collect data suitable for a velocity–time graph.
Answer: Attach the motion sensor above the fall zone. Drop the model parachute from a known height and let the sensor record velocity at regular intervals. Use a data logger to collect and plot the velocity readings over time. The graph will show acceleration at first, then a gradual flattening as air resistance builds and terminal velocity is reached.

Q512. Explain how you would use the counting-squares technique to find the distance travelled during the curved part of a velocity–time graph obtained for a rolling ball.
Answer: Print the velocity–time graph on squared paper. Count all full squares under the curved part of the graph and estimate the value of half squares. Multiply the total number of squares by the value each square represents in units of m/s × s to get the area, which equals the distance travelled.

Q513. A train travels at 20 m/s for 15 s, then accelerates uniformly to 32 m/s in the next 10 s; draw the velocity–time graph and calculate the total distance covered.

Answer:
Solution:
First part: speed = 20 m/s, time = 15 s → distance = 20 × 15 = 300 m
Second part: triangle area = ½ × base × height = ½ × 10 × (32 − 20) = 60 m
Plus rectangle area = 20 × 10 = 200 m
Total distance = 300 + 200 + 60 = 560 m
The graph would have a flat line from 0–15 s, then a straight rising line from 15–25 s.

Q514. State the difference between instantaneous acceleration and average acceleration, and give one example of how each could be measured in the laboratory.
Answer: Instantaneous acceleration is the rate of change of velocity at a single moment, while average acceleration is the change in velocity over a time period. Instantaneous acceleration can be found using a velocity–time graph by measuring the gradient at one point. Average acceleration can be found using light gates and timers to measure change in speed over time.

Q515. A student assumes uniform acceleration when applying $v^2 - u^2 = 2as$ to a runner who actually changes acceleration halfway through the race; discuss how this assumption affects the accuracy of the result.
Answer: The assumption of uniform acceleration means the student is treating acceleration as constant, which gives only an estimate. If the runner accelerates and then slows down, the equation will not account for this change. This leads to an inaccurate result for distance or acceleration, especially if the variation is large.

Q516. Describe how a force–time graph could be used alongside a velocity–time graph to give a fuller picture of the motion of a bungee jumper.
Answer: A velocity–time graph shows how speed changes, while a force–time graph shows how the forces acting on the jumper vary. Using both together helps us understand what is causing the acceleration or deceleration. For example, a peak in the force graph may line up with a sudden change in the velocity graph, helping explain motion changes due to tension in the rope.

Q517. A lift rises, slows to a stop, then descends at constant speed; sketch its velocity–time graph and label the sections of positive, zero, and negative acceleration.
Answer: The graph starts with a rising straight line (positive acceleration), flattens at the top (zero acceleration), then slopes downward (negative acceleration), and finally becomes a straight horizontal line below the time axis (constant speed in the opposite direction). Each section shows how the lift's speed and direction change over time.

Q518. Two cars have the same change in velocity, but one does so in half the time of the other; compare their accelerations and explain why this difference matters for passenger comfort.
Answer: The car that changes velocity in less time has a higher acceleration. Since acceleration = change in velocity ÷ time, halving the time doubles the acceleration. Higher acceleration means stronger forces are felt by passengers, which can cause discomfort or even harm if too high, especially in sudden starts or stops.

Q519. Give one reason why estimating acceleration from a velocity–time graph can be less reliable when the data points are widely spaced in time.
Answer: If data points are far apart, small changes in motion between points are missed. The acceleration may appear constant when in reality it changes. This lack of detail leads to inaccurate estimates of the gradient, especially during curves or sudden shifts, making the measured acceleration less reliable.

Q520. Explain why an object moving in a circle at constant speed has a non-zero acceleration even though its speed does not change.
Answer: Acceleration involves a change in velocity, which includes both speed and direction. In circular motion, the direction of movement is constantly changing, so the velocity changes even if the speed stays the same. This means the object is accelerating towards the centre of the circle; this is called centripetal acceleration.

Q521. A ball is thrown vertically upward with an initial velocity of 18 m/s; using suitable equations, determine its velocity after 1.5 s and the height reached at that instant.
Answer:
Solution:
Use $v = u + at \rightarrow v = 18 + (-9.8 \times 1.5) = 18 - 14.7 = 3.3$ m/s
Use $s = ut + ½at^2 \rightarrow s = 18 \times 1.5 + ½ \times (-9.8) \times (1.5)^2 = 27 - 11.03 \approx 15.97$ m
So, after 1.5 s, velocity is 3.3 m/s and height is about 15.97 m

Q522. Discuss how the terminal velocity of an object depends on both its weight and its cross-sectional area when falling through air.
Answer: Terminal velocity is reached when air resistance balances weight. A heavier object needs more air resistance to balance its weight, so it falls faster, meaning a higher terminal velocity. A larger cross-sectional area increases air resistance, which causes the object to reach terminal velocity sooner and at a lower speed. So, heavier objects fall faster, and larger surface areas fall slower.

Q523. Describe one improvement you would make to reduce uncertainties when using light gates to measure the acceleration of a trolley on an inclined ramp.
Answer: One improvement would be to use a smoother ramp and ensure the trolley rolls freely without friction or bumps. Also, use a data logger with a high sampling rate for precise timing. This reduces human error and gives more accurate measurements of velocity and time, improving the reliability of the calculated acceleration.

Q524. Explain why the area under a velocity–time graph gives displacement and describe what a negative area represents.
Answer: The area under a velocity–time graph represents the total displacement because velocity × time = displacement. If the area is above the time axis, it shows movement in one direction. A negative area, below the time axis, shows motion in the opposite direction. Positive and negative areas together give the net displacement.

Q525. Evaluate the limitations of using squared paper and manual counting of squares to estimate the area under a complex velocity–time graph obtained in a classroom experiment.
Answer: Counting squares manually can be inaccurate due to estimation errors with partial squares. It becomes harder with curved or irregular graphs. Small differences in judgment lead to large errors in the total area. It is also time-consuming and less precise than using software or numerical integration, especially when high accuracy is required.

Q526. State Newton's Third Law and describe what happens when a person pushes against a wall.
Answer: Newton's Third Law states that when one object exerts a force on another, the second object exerts an equal and opposite force on the first. So, when a person pushes against a wall, the wall pushes back with the same force in the opposite direction. Even though the wall doesn't move, the forces are still equal and opposite. This is why the person feels resistance from the wall.

Q527. Explain how Newton's Third Law applies when a book rests on a table.
Answer: The book exerts a downward force on the table due to its weight. According to Newton's Third Law, the table exerts an equal and opposite upward force on the book. These forces are not a pair acting on the same object but on different objects. The book stays at rest because these forces balance each other.

Q528. Describe how Newton's Third Law is involved when a rocket takes off from the ground.
Answer: The rocket engines push hot gases downwards into the ground. According to Newton's Third Law, the ground and air push the rocket upwards with an equal and opposite force. This upward force propels the rocket into the sky. The faster the gases are pushed down, the greater the upward reaction force.

Q529. Two ice skaters push off from each other on a frictionless surface. Explain how their motions relate to Newton's Third Law.
Answer: When one skater pushes against the other, the second skater experiences a force in one direction, and the first skater experiences an equal force in the opposite direction. Both skaters move away from each other with equal and opposite forces. This demonstrates Newton's Third Law clearly in action.

Q530. A bird pushes down on the air with its wings to fly. Use Newton's Third Law to explain how this allows the bird to move upwards.
Answer: When the bird flaps its wings and pushes air downwards, the air pushes back up with an equal and opposite force. This upward force helps lift the bird off the ground. The stronger the push on the air, the greater the reaction force lifting the bird up.

Q531. A car tire pushes backwards on the road. Explain how Newton's Third Law explains the forward motion of the car.
Answer: As the car's tires rotate, they push backwards on the road. According to Newton's Third Law, the road pushes forwards on the tires with an equal and opposite force. This forward force from the road moves the car ahead. The car moves because of the reaction force, not the one it applies.

Q532. Describe what is meant by equilibrium in terms of forces and how Newton's Third Law applies in such a situation.
Answer: Equilibrium means that all the forces acting on an object are balanced, so the object stays still or moves at constant speed. Newton's Third Law still applies because each force is matched by an equal and opposite force. For example, a stationary object on a surface has gravity pulling it down and the surface pushing up equally.

Q533. A person leans against a wall without moving. Explain the forces acting and how they relate to Newton's Third Law.
Answer: The person pushes horizontally on the wall. The wall pushes back with an equal and opposite horizontal force. At the same time, gravity pulls the person down, and the floor pushes up with an equal force. These balanced forces keep the person in place. Each force has a third law pair acting on the opposite object.

Q534. Explain the difference between the action and reaction forces when a swimmer pushes against the wall of a pool.
Answer: When a swimmer pushes against the pool wall (action), the wall pushes back on the swimmer with an equal and opposite force (reaction). The reaction force from the wall is what propels the swimmer forward through the water. The forces are equal in size and opposite in direction but act on different objects.

Q535. A hammer hits a nail into wood. Identify the action and reaction forces involved and describe how they are equal and opposite.
Answer: The action force is the hammer hitting the nail. The reaction force is the nail pushing back on the hammer. These forces are equal in size but opposite in direction. The nail goes into the wood because of the net effect of this interaction, even though it pushes back on the hammer with the same force.

Q536. Define stopping distance and list its two main components.
Answer: Stopping distance is the total distance a vehicle travels from the moment a driver notices a need to stop to when the vehicle actually stops. It is made up of two parts: thinking distance (the distance the car travels during the driver's reaction time) and braking distance (the distance the car travels while the brakes are applied).

Q537. Explain how the stopping distance of a vehicle is affected when the speed of the vehicle doubles.
Answer: When the speed of a vehicle doubles, the thinking distance also doubles because the driver covers more distance during the same reaction time. The braking distance increases by four times because braking distance depends on the square of the speed. So, the total stopping distance increases significantly when speed doubles.

Q538. Describe what is meant by thinking distance and state two factors that can increase it.
Answer: Thinking distance is the distance a vehicle travels in the time it takes for the driver to react to a hazard. Two factors that can increase thinking distance are tiredness and alcohol consumption.

Both slow down the driver's reaction time, causing the vehicle to travel further before the brakes are applied.

Q539. Explain how braking distance is affected by the condition of the road and the tires.
Answer: Braking distance is longer on wet, icy, or slippery roads because there is less friction between the tires and the road surface. Worn-out tires also reduce grip, increasing the braking distance. Good road conditions and properly maintained tires reduce the braking distance by increasing friction.

Q540. A vehicle is travelling at a high speed. Explain how this affects both thinking distance and braking distance.
Answer: At high speeds, thinking distance increases because the driver travels further in the time it takes to react. Braking distance increases even more because it is proportional to the square of the speed. This means that a small increase in speed can lead to a much longer stopping distance overall.

Q541. Describe how graphs of speed versus stopping distance can be used to compare the performance of different vehicles.
Answer: These graphs show how stopping distance changes with speed for different vehicles. By comparing the curves, you can see which vehicle stops more quickly at a given speed. A steeper curve means a longer stopping distance, while a flatter curve shows better braking performance. This helps in assessing safety.

Q542. A graph shows the stopping distance of a car at different speeds. Describe the shape of the graph and explain why it looks like that.
Answer: The graph curves upward, showing a non-linear increase in stopping distance as speed increases. This shape occurs because braking distance increases with the square of the speed, not directly. Thinking distance increases in a straight line, but braking distance dominates at high speeds, making the curve steeper.

Q543. Explain why the stopping distance increases more rapidly than speed.
Answer: Stopping distance increases more rapidly because braking distance is proportional to the square of the speed. When speed doubles, braking distance becomes four times greater. This non-linear relationship means that small increases in speed result in much larger increases in stopping distance, especially at higher speeds.

Q544. Describe a method you could use in a school lab to estimate a person's reaction time using a falling ruler.
Answer: One person holds a ruler vertically above another's open hand. Without warning, the ruler is dropped, and the second person catches it as quickly as possible. The distance the ruler falls before being caught is recorded. This distance can be used to calculate reaction time using equations of motion. Repeat the test to get an average.

Q545. A student repeats the ruler drop test three times and gets different results. Explain why this might happen and how to improve reliability.
Answer: Reaction times vary naturally, and distractions or lack of concentration can cause inconsistent results. Human error in reading the ruler may also affect results. To improve reliability, take multiple readings and calculate an average. Ensure the student stays focused and conditions remain the same for each test.

Q546. Compare the advantages and limitations of using computer-based methods to measure reaction time versus manual methods.
Answer: Computer-based methods are more accurate and consistent because they remove human judgment and timing errors. They can measure down to milliseconds. Manual methods like ruler drops are simpler and cheaper but less precise and more prone to error. However, they are still useful for basic classroom experiments.

Q547. Give three examples of how distractions might affect a driver's reaction time and explain the possible consequences.
Answer: Distractions like using a mobile phone, talking to passengers, or adjusting the radio can delay a driver's reaction. This leads to longer thinking distances and higher chances of accidents. Even a small delay can cause the car to travel many more metres before braking begins, especially at high speeds.

Q548. Explain how alcohol affects reaction time and how this would change the thinking distance of a driver.
Answer: Alcohol slows down the nervous system, making the brain process information more slowly. This increases the time it takes for a driver to respond to hazards. As a result, the thinking distance becomes longer because the car keeps moving while the driver reacts. This puts the driver and others at greater risk.

Q549. A driver's reaction time is 0.7 seconds. If their speed is 20 m/s, calculate their thinking distance and explain how this contributes to total stopping distance.
Answer:
Solution:
Thinking distance = speed × reaction time = 20 m/s × 0.7 s = 14 m
The car will travel 14 metres before braking even begins. This adds to the braking distance to form the total stopping distance. So, even before the brakes are applied, the car has already covered a significant distance.

Q550. Evaluate how road safety campaigns can help reduce stopping distances and save lives by targeting factors that affect reaction time.
Answer: Road safety campaigns can educate drivers about the dangers of alcohol, drugs, and distractions, which all increase reaction time and thus thinking distance. By raising awareness, they can encourage safer driving habits, such as staying alert and focused. These changes can reduce accidents by helping drivers react more quickly and stop in shorter distances.

Q551. Describe how wet or icy road conditions affect the braking distance of a vehicle and explain why.
Answer: Wet or icy road conditions reduce the friction between the tyres and the road surface. This means that when the brakes are applied, it takes longer for the vehicle to slow down and stop. As a result, the braking distance increases. The tyres can slide instead of gripping the road properly, making it harder to stop safely.

Q552. Explain how worn-out tyres can increase the braking distance of a car.
Answer: Worn-out tyres have less tread, which reduces their grip on the road, especially in wet conditions. This means less friction is available during braking, so the vehicle takes longer to stop. Poor tyre condition increases the risk of skidding and extends the braking distance, making driving more dangerous.

Q553. A car is travelling on a dry road and then moves onto a wet surface. Predict how the braking distance will change and why.
Answer: As the car moves from a dry road onto a wet surface, the braking distance will increase. This is because water reduces the friction between the tyres and the road. With less friction, the brakes cannot slow the car down as effectively, so it takes longer to stop.

Q554. Explain how faulty brakes can affect both the braking distance and overall safety of a vehicle.
Answer: Faulty brakes may not apply enough force to slow down the vehicle quickly, increasing the braking distance. They might also respond slowly or unevenly, making it harder to control the car. This can lead to longer stopping times and higher chances of accidents, especially in emergencies.

Q555. Discuss why it is important to check tyre pressure regularly in relation to stopping distances.
Answer: Proper tyre pressure ensures that the tyres have maximum contact with the road surface, which improves grip and friction. Under-inflated or over-inflated tyres reduce traction, leading to longer braking distances. Regular checks help maintain safe stopping performance and reduce the risk of skidding.

Q556. A driver increases their speed from 30 mph to 60 mph. Explain how the stopping distance changes and why.
Answer: When speed doubles, the braking distance increases by four times because braking distance depends on the square of the speed. So, going from 30 mph to 60 mph results in a much longer stopping distance. This makes it more dangerous to stop quickly at higher speeds.

Q557. Describe how the braking force needed to stop a vehicle changes with the speed of the vehicle.
Answer: As the speed of the vehicle increases, the braking force required to stop it within a certain distance also increases. This is because the vehicle has more kinetic energy at higher speeds, which must be removed by the brakes. The faster the vehicle is moving, the more force is needed.

Q558. Explain how the condition of the road surface affects the friction between the tyres and the road.
Answer: A dry, rough surface provides more friction, helping the tyres grip the road better and reduce braking distance. Wet, icy, or loose surfaces lower friction, making it harder for tyres to grip. This leads to longer stopping distances and a higher risk of skidding.

Q559. Describe the role of friction in braking and what happens if friction is too low.
Answer: Friction between the brake pads and the wheels, and between the tyres and the road, is what slows the vehicle down during braking. If friction is too low, such as on wet or icy roads, the tyres may skid and the vehicle may not stop in time, increasing the risk of accidents.

Q560. A vehicle comes to a stop over 25 m on a dry road. Estimate how the stopping distance might change if the road is icy and explain why.
Answer: On an icy road, the stopping distance could increase by two to ten times or more depending on the conditions. So, the 25 m distance could become 50 m or even more. This is because ice greatly reduces friction between the tyres and the road, making it harder to stop.

Q561. Explain what is meant by work done in the braking process and what energy transfer occurs.
Answer: Work is done when the braking force slows down the vehicle. The brakes apply a force over a distance, removing kinetic energy from the moving vehicle. This kinetic energy is converted into thermal energy due to friction, which heats up the brake pads and discs.

Q562. Describe how the kinetic energy of a moving vehicle is reduced during braking.
Answer: During braking, the friction between the brake pads and the wheels slows the rotation of the wheels. This reduces the vehicle's kinetic energy, which is the energy of movement. The energy is not destroyed but converted into heat energy, which increases the temperature of the brakes.

Q563. A lorry and a car are travelling at the same speed. Explain which one would require more braking force to stop and why.
Answer: The lorry would require more braking force because it has a greater mass. Since kinetic energy depends on mass and speed, the lorry has more kinetic energy at the same speed. More energy must be removed to stop it, so the brakes need to apply a greater force.

Q564. Describe the possible consequences of applying a very large braking force suddenly while driving at high speed.
Answer: A sudden, large braking force at high speed can cause the wheels to lock, leading to skidding and loss of control. It can also overheat the brakes, reducing their effectiveness. In extreme cases, it may damage the braking system or cause the vehicle to swerve dangerously.

Q565. Explain why brakes can overheat if a vehicle decelerates rapidly and repeatedly.
Answer: Braking involves converting kinetic energy into heat. If a vehicle brakes hard and often, especially at high speeds, the brake components generate a lot of heat. If this heat cannot escape quickly, the brakes overheat. Overheated brakes work less effectively and may fail.

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Q566. Describe how high deceleration can lead to a driver losing control of the vehicle.
Answer: High deceleration means the vehicle slows down very quickly. If the braking force is too strong, the tyres may lose grip and the car may skid. This makes steering difficult, especially if the road is slippery, and can cause the driver to lose control of the vehicle.

Q567. A car decelerates at 6 m/s² over 4 seconds. Estimate the braking force if the car has a mass of 1000 kg.
Answer:
Solution:
Force = mass × acceleration
= 1000 kg × 6 m/s² = 6000 N
The braking force is 6000 newtons. This is the force required to reduce the car's speed with a deceleration of 6 m/s².

Q568. Describe the safety features in modern cars that help to reduce the risk of skidding during emergency braking.
Answer: Modern cars use anti-lock braking systems (ABS), which prevent the wheels from locking when brakes are applied hard. This helps maintain grip and steering control. Traction control systems and electronic stability programs also help prevent skidding during braking on slippery surfaces.

Q569. Explain the link between speed, braking force, and deceleration when stopping a vehicle.
Answer: To stop a vehicle, the brakes apply a force that causes deceleration. The faster the vehicle is moving, the more braking force is needed to produce enough deceleration to stop it in time. Higher speeds mean more kinetic energy, so greater force or more time is needed to stop safely.

Q570. Estimate how long it would take a car to stop if it decelerates at 5 m/s² from an initial speed of 25 m/s.
Answer:
Solution:
Time = change in velocity ÷ deceleration
= 25 m/s ÷ 5 m/s² = 5 seconds
It would take the car 5 seconds to stop at that rate of deceleration.

Q571. Discuss the dangers of excessive braking on a steep slope.
Answer: On a steep slope, gravity pulls the car downhill, increasing its speed. If the driver brakes too hard, the brakes may overheat or lock the wheels, causing a skid. Continuous braking on a long slope can also reduce brake efficiency, leading to brake failure and loss of control.

Q572. Describe how an anti-lock braking system (ABS) helps maintain control during braking.
Answer: ABS prevents the wheels from locking when brakes are applied forcefully. It rapidly applies and releases the brakes to keep the wheels turning slightly. This allows the driver to steer while braking and prevents skidding, especially on wet or slippery roads.

Q573. A driver applies the brakes and the temperature of the brake pads increases. Explain the energy transfer involved.
Answer: When brakes are applied, the kinetic energy of the moving car is transferred into thermal energy through friction. This heat energy raises the temperature of the brake pads and discs. This energy transfer is what slows the car down and is a normal part of the braking process.

Q574. Explain why it is dangerous to follow another car too closely in bad weather conditions.
Answer: In bad weather, braking distance increases due to reduced friction. If you follow too closely, there may not be enough space to stop safely if the car in front brakes suddenly. This increases the risk of a rear-end collision. Keeping a safe distance allows more time to react.

Q575. Evaluate how driving habits can influence braking distances and road safety.
Answer: Safe driving habits, like maintaining a proper distance, reducing speed in poor weather, and keeping brakes and tyres in good condition, help reduce braking distances and prevent accidents. Risky habits such as speeding, tailgating, or ignoring maintenance increase stopping distances and make driving less safe.

Q576. State the equation that links momentum, mass, and velocity, and define each quantity's SI unit.
Answer: The equation is momentum = mass × velocity or $p = m \times v$. Momentum is measured in kilogram metres per second (kg·m/s), mass in kilograms (kg), and velocity in metres per second (m/s). This means that the momentum of an object depends on how much mass it has and how fast it is moving.

Q577. A 2 kg toy car travels at 3 m/s. Calculate its momentum.
Answer:
Solution:
$p = m \times v$
$p = 2\text{ kg} \times 3\text{ m/s} = 6\text{ kg·m/s}$
The momentum of the toy car is 6 kg·m/s.

Q578. Explain what is meant by a closed system when discussing conservation of momentum.
Answer: A closed system is one where no external forces act on the objects involved. This means that all forces are internal and any interaction, such as a collision, does not involve external push or pull. In such a system, the total momentum before the interaction is equal to the total momentum after, which is known as the conservation of momentum.

Q579. Two ice skaters push off from each other on frictionless ice. Describe how their momenta compare before and after they separate.
Answer: Before they push off, their total momentum is zero because neither skater is moving. After pushing off, they move in opposite directions with equal and opposite momentum. This means their momenta are equal in size but opposite in direction, so the total momentum is still zero. This shows conservation of momentum.

Q580. A 1 kg ball moving at 4 m/s strikes and sticks to a 3 kg ball at rest. Calculate the common velocity after the collision.

Answer:

Solution:

Total momentum before = (1 kg × 4 m/s) + (3 kg × 0) = 4 kg·m/s

Total mass after = 1 kg + 3 kg = 4 kg

Velocity after = total momentum ÷ total mass = 4 kg·m/s ÷ 4 kg = 1 m/s

The common velocity after the collision is 1 m/s.

Q581. Explain why momentum is conserved in a collision between two trolleys if no external forces act.

Answer: When no external forces act, the only forces involved are the ones the trolleys exert on each other. These are internal forces. According to the law of conservation of momentum, the total momentum of a closed system (no external forces) remains constant. So, the total momentum before and after the collision stays the same.

Q582. A 1.5 kg skateboard moves at 2 m/s and collides elastically with a 0.5 kg ball at rest. Describe how you would calculate their velocities after the collision.

Answer: First, calculate the total momentum and total kinetic energy before the collision. Then, apply the conservation of momentum and conservation of kinetic energy equations to form a system of two equations. Solving these simultaneously will give the final velocities of both objects, since in elastic collisions both momentum and kinetic energy are conserved.

Q583. Describe an experiment using light gates to measure the momentum before and after two trolleys collide.

Answer: Set up two trolleys on a straight track with light gates placed before and after the collision point. The light gates record the speed of each trolley before and after the collision. Using the formula p = m × v, calculate the momentum of each trolley. Then compare the total momentum before and after the collision to check if it is conserved.

Q584. A 1200 kg car moving at 10 m/s crashes into a stationary 1000 kg car and they lock together. Find their joint velocity immediately after impact.

Answer:

Solution:

Total momentum before = 1200 kg × 10 m/s + 1000 kg × 0 = 12,000 kg·m/s

Total mass = 1200 kg + 1000 kg = 2200 kg

Velocity after = 12,000 kg·m/s ÷ 2200 kg = 5.45 m/s

The cars move together at 5.45 m/s after the collision.

Q585. State the equation that links force, change in momentum, and time, and explain each term briefly.

Answer: The equation is Force = change in momentum ÷ time or F = Δp ÷ t. Force is measured in newtons (N), change in momentum (Δp) in kg·m/s, and time (t) in seconds. This equation shows that a bigger force or longer time changes an object's momentum more.

Q586. A force of 600 N acts for 0.2 s on a 1 kg football. Calculate the change in velocity of the ball.

Answer:

Solution:

$F = \Delta p \div t \rightarrow \Delta p = F \times t = 600\ N \times 0.2\ s = 120\ kg \cdot m/s$

$\Delta v = \Delta p \div m = 120\ kg \cdot m/s \div 1\ kg = 120\ m/s$

The velocity of the ball changes by 120 m/s.

Q587. Explain why increasing the time over which a force acts reduces the size of the force needed to change an object's momentum.

Answer: According to $F = \Delta p \div t$, if the time (t) over which a change in momentum (Δp) occurs increases, the force (F) required becomes smaller. This is why safety features like airbags increase the time over which they stop the passenger, reducing the force on the body and preventing injury.

Q588. Describe how an air bag in a car helps reduce injuries during a crash using the concept of rate of change of momentum.

Answer: In a crash, the car and passenger have momentum. The airbag increases the time taken to stop the passenger, spreading the change in momentum over a longer time. This reduces the force on the passenger because $F = \Delta p \div t$, and reduces injuries.

Q589. A steel ball of mass 0.2 kg rebounds from a wall. Its incoming velocity is 5 m/s, and its outgoing velocity is −4 m/s. Calculate the impulse delivered by the wall.

Answer:

Solution:

Impulse = change in momentum = $m \times (v - u)$

$= 0.2\ kg \times (-4\ m/s - 5\ m/s) = 0.2\ kg \times (-9\ m/s) = -1.8\ kg \cdot m/s$

Impulse is $-1.8\ kg \cdot m/s$ (negative sign shows direction reversed).

Q590. Explain how gym crash mats help protect athletes from injury when landing from height.

Answer: Crash mats increase the time taken for the athlete to come to a stop. This means the change in momentum happens over a longer time, so the force on the athlete is smaller. This reduces the chance of injury by spreading the stopping force more gently.

Q591. A rugby player of mass 90 kg running at 8 m/s is stopped in 0.4 s. Calculate the average force exerted on him.

Answer:

Solution:

Initial momentum = $90\ kg \times 8\ m/s = 720\ kg \cdot m/s$

Force = $\Delta p \div t = 720\ kg \cdot m/s \div 0.4\ s = 1800\ N$

The average force exerted is 1800 N.

Q592. Discuss how cushioned playground surfaces reduce the risk of head injuries for children.

Answer: Cushioned surfaces compress when a child falls, increasing the time it takes to stop the child's motion. This longer time reduces the force on the child's head using F = Δp ÷ t. Lower force means less chance of a serious injury, making the playground safer.

Q593. A 50 g bullet leaves a gun barrel at 300 m/s. Calculate the recoil velocity of a 3 kg gun.
Answer:
Solution:
Convert 50 g to kg: 0.05 kg
Momentum of bullet = 0.05 kg × 300 m/s = 15 kg·m/s
Recoil velocity = −15 kg·m/s ÷ 3 kg = −5 m/s
The gun recoils at 5 m/s in the opposite direction.

Q594. Explain why wearing a cycle helmet reduces the force on the skull during an impact.
Answer: A cycle helmet contains padding that compresses during an impact. This increases the time over which the head slows down, reducing the rate of change of momentum. As F = Δp ÷ t, this longer time means less force is applied to the skull, helping prevent serious injury.

Q595. Two carts of equal mass approach each other at 2 m/s each and stick together. Show how the final momentum of the system is zero.
Answer:
Solution:
Cart A momentum = m × 2 m/s
Cart B momentum = m × (−2 m/s)
Total momentum = m × 2 − m × 2 = 0
After they stick, they do not move because momentum is zero, showing conservation of momentum.

Q596. A train wagon of mass 5000 kg moving at 1.2 m/s couples with a stationary wagon of 3000 kg. Calculate the loss of kinetic energy in the system.
Answer:
Solution:
Initial KE = ½ × 5000 × 1.2^2 = 3600 J
Final velocity = (5000 × 1.2) ÷ (5000 + 3000) = 0.75 m/s
Final KE = ½ × 8000 × 0.75^2 = 2250 J
Loss = 3600 − 2250 = 1350 J
The kinetic energy lost is 1350 J.

Q597. Describe why elastic collisions conserve kinetic energy as well as momentum, while inelastic collisions do not.
Answer: In elastic collisions, no kinetic energy is lost; it's just transferred between objects. This means both momentum and kinetic energy are conserved. In inelastic collisions, some kinetic energy is transformed into other forms like sound or heat, so kinetic energy is not conserved, though momentum still is.

Q598. Explain how seat belts reduce the risk of chest injury in a collision, using the idea of impulse.
Answer: Seat belts stretch slightly during a crash, increasing the time over which the chest comes to a stop. The impulse (force × time) remains the same, but by increasing time, the force is reduced. A lower force on the chest means reduced injury.

Q599. A toy rocket of mass 0.4 kg expels 0.05 kg of gas backwards at 40 m/s. Calculate the forward velocity gained by the rocket.
Answer:
Solution:
Momentum of gas = 0.05 × −40 = −2 kg·m/s
Rocket momentum = +2 kg·m/s → v = 2 ÷ 0.4 = 5 m/s
The rocket gains 5 m/s forward velocity.

Q600. Discuss one real-world situation where ignoring external forces would lead to an incorrect conclusion about momentum conservation.
Answer: In a car crash on a rough road, ignoring external forces like friction or air resistance can lead to errors in momentum calculations. These forces can remove or add momentum to the system, so assuming momentum is conserved without accounting for them would give inaccurate results.