

GCSE / IGCSE Physics – Forces and Motion

GCSE/IGCSE · Total marks: 64 · Answers on the last page

Covers speed and acceleration, distance-time and velocity-time graphs, resultant forces and Newton's laws, momentum and collisions, stopping distances, Hooke's law and moments. Calculator allowed; use $g = 9.81 \text{ N kg}^{-1}$ (some boards use 10); allow about 60 minutes.

Section A – Skills (Show equations, substitution and units.)

1. A cyclist travels 1500 m in 120 s.
 - (a) Calculate the average speed of the cyclist.
 - (b) The cyclist then accelerates uniformly from 12 m s^{-1} to 30 m s^{-1} in 6.0 s. Calculate the acceleration. [4]
2. A resultant force of 450 N acts on a car of mass 900 kg.
 - (a) Calculate the acceleration of the car.
 - (b) State Newton's first law of motion. [3]
3. Two forces act on a box at right angles: 30 N to the east and 40 N to the north.
 - (a) Calculate the magnitude of the resultant force.
 - (b) Describe how you would find its direction using a scale drawing. [4]
4. A spring has a spring constant of 25 N m^{-1} and is stretched by 12 cm within its limit of proportionality.
 - (a) Calculate the force applied.
 - (b) Calculate the elastic potential energy stored. [4]
5. A car of mass 1200 kg travels at 15 m s^{-1} .
 - (a) Calculate its momentum.
 - (b) Calculate its kinetic energy. [4]

Section B – Exam-style (Longer structured questions.)

6. A train starts from rest and accelerates uniformly to 16 m s^{-1} in 8 s. It then travels at 16 m s^{-1} for 12 s before decelerating uniformly to rest in 4 s.
 - (a) Sketch the velocity-time graph, labelling the axes and key values.
 - (b) Calculate the initial acceleration.
 - (c) Calculate the total distance travelled. [6]
7. A skydiver of mass 70 kg has just left an aircraft. At one instant the air resistance acting on her is 300 N.
 - (a) Calculate her weight.
 - (b) Calculate her acceleration at this instant.
 - (c) Explain, in terms of forces, why she eventually reaches terminal velocity. [6]
8. A car of mass 1200 kg moving at 15 m s^{-1} collides with a stationary van of mass 800 kg. The two vehicles move off together.
 - (a) State the principle of conservation of momentum.
 - (b) Calculate the common velocity after the collision.
 - (c) Explain why crumple zones reduce injuries in such a collision. [6]

9. A driver travelling at 20 m s^{-1} sees a hazard. Her reaction time is 0.7 s. The car has mass 1000 kg and the brakes provide a force of 6000 N.
- (a) Calculate the thinking distance.
 - (b) Calculate the deceleration and hence the braking distance.
 - (c) State two factors that would increase the braking distance. [7]
10. A uniform seesaw is pivoted at its centre. A child of mass 30 kg sits 1.5 m from the pivot on the left.
- (a) Calculate the moment of the child's weight about the pivot.
 - (b) An adult of mass 45 kg sits on the right. Calculate how far from the pivot the adult must sit for the seesaw to balance. [5]

Section C – Challenge (Extended problems.)

11. A tennis ball of mass 0.16 kg is struck by a racket and leaves at 40 m s^{-1} , having been at rest. The ball is in contact with the racket for 0.020 s.
- (a) Calculate the change in momentum of the ball.
 - (b) Calculate the average force exerted by the racket.
 - (c) Using Newton's third law, state the force the ball exerts on the racket.
 - (d) A car accelerates from rest to 25 m s^{-1} over a distance of 100 m. Use $v^2 = u^2 + 2as$ to find its acceleration. [8]
12. A uniform beam of length 4.0 m and weight 200 N rests horizontally on two supports, one at the left end and one at the right end. A load of 500 N is placed 3.0 m from the left end.
- (a) Taking moments about the left support, calculate the upward force from the right support.
 - (b) Calculate the upward force from the left support.
 - (c) Explain what would happen if the load were moved to 3.9 m from the left end. [7]

Answers

Check your working against these. If an answer does not match, try the question again before looking for the method.

- $v = \frac{1500}{120} = 12.5 \text{ m s}^{-1}$
 - $a = \frac{30 - 12}{6.0} = 3.0 \text{ m s}^{-2}$
- $a = \frac{450}{900} = 0.5 \text{ m s}^{-2}$
 - An object remains at rest or moves at constant velocity unless acted on by a resultant force
- $\sqrt{30^2 + 40^2} = 50 \text{ N}$
 - Draw the two vectors tip-to-tail to scale, draw the resultant from start to finish, measure the angle with a protractor (about 53° from east towards north)
- $F = kx = 25 \times 0.12 = 3.0 \text{ N}$
 - $E = \frac{1}{2}kx^2 = \frac{1}{2}(25)(0.12)^2 = 0.18 \text{ J}$
- $p = mv = 18\,000 \text{ kg m s}^{-1}$
 - $E_k = \frac{1}{2}(1200)(15)^2 = 135\,000 \text{ J} = 135 \text{ kJ}$
- Straight line from (0, 0) to (8, 16), horizontal to (20, 16), straight line down to (24, 0)
 - 2.0 m s^{-2}
 - Area = $64 + 192 + 32 = 288 \text{ m}$
- $W = 70 \times 9.81 = 687 \text{ N}$
 - Resultant = $687 - 300 = 387 \text{ N}$; $a = \frac{387}{70} = 5.5 \text{ m s}^{-2}$
 - As speed increases, air resistance increases until it equals the weight; resultant force is zero so acceleration is zero and velocity is constant
- Total momentum before a collision equals total momentum after, provided no external forces act
 - $1200 \times 15 = 2000v$, so $v = 9.0 \text{ m s}^{-1}$
 - They increase the time over which momentum changes, reducing the rate of change of momentum and so the force on occupants
- $20 \times 0.7 = 14 \text{ m}$
 - $a = 6.0 \text{ m s}^{-2}$; $s = \frac{v^2}{2a} = \frac{400}{12} = 33.3 \text{ m}$
 - Any two: wet or icy road, worn tyres or brakes, greater speed, greater mass
- $30 \times 9.81 \times 1.5 = 441 \text{ N m}$
 - $441 = 45 \times 9.81 \times d$, so $d = 1.0 \text{ m}$
- $0.16 \times 40 = 6.4 \text{ kg m s}^{-1}$
 - $F = \frac{6.4}{0.020} = 320 \text{ N}$
 - 320 N on the racket, in the opposite direction
 - $a = \frac{25^2}{2 \times 100} = 3.1 \text{ m s}^{-2} \text{ (3.125)}$
- $4.0R = 200 \times 2.0 + 500 \times 3.0 = 1900$, so $R = 475 \text{ N}$
 - $700 - 475 = 225 \text{ N}$
 - Right support force rises to $(400 + 1950)/4 = 587.5 \text{ N}$ and left falls to 112.5 N ; beam still balanced but nearly all the load is carried by the right support

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