Edexcel AS Physics: Mechanics – Calculation Practice

Praneel Physics

1. A car accelerates from rest at a rate of $2\,\mathrm{m/s^2}$. What is its speed after 5 seconds? **(P)**

Working and Answer:
Using the formula $v = u + at$, where $u = 0, a = 2\,\mathrm{m/s^2}$, and $t = 5\,\mathrm{s}$.$v = 0 + (2)(5) = 10\,\mathrm{m/s}$.

2. A ball is thrown vertically upwards with an initial velocity of 15 m/s. How high does it rise before coming to a stop? (Take $g = 9.81\,\text{m/s}^2$) **(P)**

Working and Answer:
Using the formula $v^2 = u^2 + 2as$, where $v = 0, u = 15\,\text{m/s}, a = -9.81\,\text{m/s}^2.0 = (15)^2 + 2(-9.81)s, 225 = 19.62s, s = \dfrac{225}{19.62} \approx 11.47\,\text{m}.$

3. A cyclist travels at a constant speed of 12 m/s for 30 seconds. How far does the cyclist travel? **(P)**

Working and Answer:
Using the formula $s = vt$, where $v = 12\,\text{m/s}$ and $t = 30\,\text{s}.s = 12 \times 30 = 360\,\text{m}.$

4. A block of mass 5 kg is pulled across a horizontal surface with a force of 20 N. If the frictional force is 5 N, what is the acceleration of the block? **(P)**

Working and Answer:
Net force $F = 20\,\text{N} - 5\,\text{N} = 15\,\text{N}$. Using $F = ma$, where $m = 5\,\text{kg}.15 = 5a, a = \frac{15}{5} = 3\,\text{m/s}^2$.

5. A stone is dropped from a height of 20 m. How long does it take to reach the ground? (Take $g = 9.81\,\text{m/s}^2$) **(P)**

Working and Answer:
Using the formula $s = ut + \frac{1}{2}gt^2$, where $u = 0, s = 20\,\text{m}.20 = 0 + \frac{1}{2}(9.81)t^2, 20 = 4.905t^2, t^2 = \frac{20}{4.905} \approx 4.08, t \approx 2.02\,\text{s}$.

6. A car travels a distance of 150 m in 10 s. What is its average speed? **(PP)**

Working and Answer:
Using the formula $v = \frac{s}{t}$, where $s = 150\,\text{m}$ and $t = 10\,\text{s}$.$v = \frac{150}{10} = 15\,\text{m/s}$.

7. A projectile is launched at an angle of 30° with an initial speed of 20 m/s. What is the horizontal component of its velocity? **(PP)**

Working and Answer:
Using the formula $v_x = v\cos(\theta)$, where $v = 20\,\text{m/s}$ and $\theta = 30°$.$v_x = 20\cos(30°) = 20 \times \frac{\sqrt{3}}{2} \approx 17.32\,\text{m/s}$.

8. A 10 kg object is lifted vertically 5 m. Calculate the work done against gravity. (Take $g = 9.81\,\text{m/s}^2$) **(PP)**

Working and Answer:
Using the formula $W = Fd$, where $F = mg = 10 \times 9.81 = 98.1\,\text{N}$ and $d = 5\,\text{m}$.$W = 98.1 \times 5 = 490.5\,\text{J}$.

9. A car moving at 25 m/s comes to a stop in 5 s. What is the deceleration of the car? **(PP)**

Working and Answer:
Using the formula $a = \dfrac{v-u}{t}$, where $v = 0, u = 25\,\text{m/s}, t = 5\,\text{s}$.$a = \dfrac{0-25}{5} = -5\,\text{m/s}^2$.

10. A 2 kg mass is attached to a spring with a spring constant of 300 N/m. What is the potential energy stored in the spring when it is compressed by 0.1 m? **(PP)**

Working and Answer:
Using the formula $PE = \frac{1}{2}kx^2$, where $k = 300\,\text{N/m}$ and $x = 0.1\,\text{m}$.$PE = \frac{1}{2}(300)(0.1^2) = \frac{1}{2}(300)(0.01) = 1.5\,\text{J}$.

11. A 50 kg crate is pushed with a force of 200 N across a rough surface. If the frictional force is 50 N, what is the acceleration of the crate? **(PPP)**

Working and Answer:
Net force $F = 200\,\text{N} - 50\,\text{N} = 150\,\text{N}$. Using $F = ma$, where $m = 50\,\text{kg}$.$150 = 50a, a = \frac{150}{50} = 3\,\text{m/s}^2$.

12. A ball is thrown horizontally from a height of 45 m. How long does it take to hit the ground? (Take $g = 9.81\,\text{m/s}^2$) **(PPP)**

Working and Answer:
Using the formula $s = \frac{1}{2}gt^2$, where $s = 45\,\text{m}.45 = \frac{1}{2}(9.81)t^2, 45 = 4.905t^2, t^2 = \frac{45}{4.905} \approx 9.16, t \approx 3.02\,\text{s}$.

13. A 3 kg object is moving with a velocity of 10 m/s. What is its kinetic energy? **(PPP)**

Working and Answer:
Using the formula $KE = \frac{1}{2}mv^2$, where $m = 3\,\text{kg}$ and $v = 10\,\text{m/s}.KE = \frac{1}{2}(3)(10)^2 = \frac{1}{2}(3)(100) = 150\,\text{J}$.

14. A car of mass 800 kg accelerates from rest to a speed of 20 m/s in 10 s. Calculate the work done on the car. **(PPP)**

Working and Answer:
First, find the acceleration: $a = \frac{v-u}{t} = \frac{20-0}{10} =$ $2\,\text{m/s}^2$. Next, find the force: $F = ma = 800 \times 2 =$ 1600 N. Finally, calculate the work done: $W = Fd$. Distance $d = ut + \frac{1}{2}at^2 =$ $0 + \frac{1}{2}(2)(10^2) = 100\,\text{m}.W = 1600 \times 100 = 160000\,\text{J}$.

15. A 4 kg object is moving in a circular path of radius 2 m with a speed of 3 m/s. What is the centripetal force acting on the object? **(PPP)**

Working and Answer:

Using the formula $F_c = \dfrac{mv^2}{r}$, where $m = 4\,\text{kg}, v = 3\,\text{m/s}, r = 2\,\text{m}.F_c = \dfrac{4(3)^2}{2} = \dfrac{4 \times 9}{2} = 18\,\text{N}.$

16. A 10 kg object is moving with a velocity of 15 m/s. It collides with a stationary 5 kg object. If the collision is perfectly elastic, what is the final velocity of the 10 kg object after the collision? **(PPPP)**

Working and Answer:
Using conservation of momentum: $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$. Let $u_1 = 15\,\text{m/s}, u_2 = 0, m_1 = 10\,\text{kg}, m_2 = 5\,\text{kg}.10 \times 15 + 5 \times 0 = 10v_1 + 5v_2, 150 = 10v_1 + 5v_2$. Using conservation of kinetic energy: $\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2, \frac{1}{2}(10)(15^2) + 0 = \frac{1}{2}(10)v_1^2 + \frac{1}{2}(5)v_2^2, 1125 = 5v_1^2 + 2.5v_2^2$. Solving these two equations gives $v_1 \approx 10\,\text{m/s}$.

17. A 12 kg object is moving in a straight line with a speed of 8 m/s. It collides with a 3 kg object at rest. If the collision is perfectly inelastic, what is the final velocity of the combined mass? **(PPPP)**

Working and Answer:
Using conservation of momentum: $m_1u_1 + m_2u_2 = (m_1 + m_2)v$. Let $u_1 = 8\,\text{m/s}, u_2 = 0, m_1 = 12\,\text{kg}, m_2 = 3\,\text{kg}.12 \times 8 + 3 \times 0 = (12 + 3)v, 96 = 15v, v = \frac{96}{15} = 6.4\,\text{m/s}$.

18. A 5 kg object is moving in a circular path of radius 3 m with a speed of 4 m/s. Calculate the work done by the centripetal force over one complete revolution. **(PPPP)**

Working and Answer:
Centripetal force does not do work as it acts perpendicular to the displacement. Therefore, the work 0 J.

19. A 2 kg mass is attached to a spring with a spring constant of 200 N/m. If the spring is compressed by 0.2 m, what is the potential energy stored in the spring? **(PPPP)**

Working and Answer:
Using the formula $PE = \frac{1}{2}kx^2$, where $k = 200\,\text{N/m}$ and $x = 0.2\,\text{m}$.$PE = \frac{1}{2}(200)(0.2)^2 = \frac{1}{2}(200)(0.04) = 4\,\text{J}$.

20. A 10 kg object is moving with a velocity of 5 m/s and collides elastically with a 5 kg object at rest. What are the final velocities of both objects after the collision? **(PPPPP)**

Working and Answer:
Using conservation of momentum and kinetic energy: Let $u_1 = 5\,\text{m/s}, u_2 = 0, m_1 = 10\,\text{kg}, m_2 = 5\,\text{kg}$. Momentum: $10 \times 5 + 5 \times 0 = 10v_1 + 5v_2, 50 = 10v_1 + 5v_2$. Kinetic Energy: $\frac{1}{2}(10)(5^2) + 0 = \frac{1}{2}(10)v_1^2 + \frac{1}{2}(5)v_2^2, 125 = 5v_1^2 + 2.5v_2^2$. Solving these equations gives $v_1 = 3.33\,\text{m/s}, v_2 = 6.67\,\text{m/s}$.

21. A 15 kg object is moving with a velocity of 10 m/s and collides elastically with a 10 kg object at rest. What are the final velocities of both objects after the collision? **(PPPPP)**

Working and Answer:
Using conservation of momentum and kinetic energy: Let $u_1 = 10\,\text{m/s}, u_2 = 0, m_1 = 15\,\text{kg}, m_2 = 10\,\text{kg}$. Momentum: $15 \times 10 + 10 \times 0 = 15v_1 + 10v_2, 150 = 15v_1 + 10v_2$. Kinetic Energy: $\frac{1}{2}(15)(10^2) + 0 = \frac{1}{2}(15)v_1^2 + \frac{1}{2}(10)v_2^2, 750 = 7.5v_1^2 + 5v_2^2$. Solving these equations gives $v_1 \approx 6.67\,\text{m/s}, v_2 \approx 8.33\,\text{m/s}$.