Edexcel A2 Physics: Further Mechanics – Calculation Practice

Praneel Physics

1. A car accelerates from rest at a rate of $2\,\text{m/s}^2$ for 5 seconds. What is the final velocity of the car? **(P)**

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

2. A ball is thrown vertically upwards with an initial velocity of 15 m/s. Calculate the maximum height reached by the ball. (Take $g = 9.81\,\text{m/s}^2$) **(P)**

Working and Answer:
Using $v^2 = u^2 + 2as$, where $v = 0, u = 15\,\text{m/s}, a = -9.81\,\text{m/s}^2 : 0 = (15)^2 + 2(-9.81)s, 0 = 225 - 19.62s, 19.62s = 225, s = \frac{225}{19.62} \approx 11.48\,\text{m}$. Maximum height $s \approx 11.48\,\text{m}$.

3. A block of mass 3 kg is pulled along a horizontal surface with a force of 12 N. If the frictional force is 4 N, what is the acceleration of the block? **(P)**

Working and Answer:
Net force $F = 12\,\text{N} - 4\,\text{N} = 8\,\text{N}$. Using $F = ma : 8 = 3a, a = \frac{8}{3} \approx 2.67\,\text{m/s}^2$. Acceleration $a \approx 2.67\,\text{m/s}^2$.

4. A projectile is launched at an angle of 30° with an initial speed of 20 m/s. Calculate the horizontal range of the projectile. (Take $g = 9.81\,\text{m/s}^2$) **(P)**

Working and Answer:

Horizontal component of velocity $v_x = 20\cos(30°) = 20 \times \frac{\sqrt{3}}{2} \approx 17.32\,\text{m/s}$. Vertical component of velocity $v_y = 20\sin(30°) = 20 \times \frac{1}{2} = 10\,\text{m/s}$. Time of flight $t = \frac{2v_y}{g} = \frac{2 \times 10}{9.81} \approx 2.04\,\text{s}$. Range $R = v_x t \approx 17.32 \times 2.04 \approx 35.34\,\text{m}$. Horizontal range $R \approx 35.34\,\text{m}$.

5. A pendulum of length 2 m swings with small amplitude. Calculate the period of the pendulum. (Use $g = 9.81\,\text{m/s}^2$) **(P)**

Working and Answer:
Using the formula for the period of a simple pendulum: $T = 2\pi\sqrt{\frac{L}{g}}, T = 2\pi\sqrt{\frac{2}{9.81}} \approx 2.83\,\text{s}$. Period $T \approx 2.83\,\text{s}$.

6. A car travels a distance of 150 m in 5 s. What is the average speed of the car? **(PP)**

Working and Answer:
Average speed $v = \frac{d}{t} = \frac{150\,\text{m}}{5\,\text{s}} = 30\,\text{m/s}$. Average speed $v = 30\,\text{m/s}$.

7. A 5 kg object is dropped from a height of 20 m. Calculate the speed of the object just before it hits the ground. (Take $g = 9.81\,\text{m/s}^2$) **(PP)**

Working and Answer:
Using $v^2 = u^2 + 2gh$, where $u = 0, h = 20\,\text{m} : v^2 = 0 + 2(9.81)(20), v^2 = 392.4, v = \sqrt{392.4} \approx 19.81\,\text{m/s}$. Speed just before impact $v \approx 19.81\,\text{m/s}$.

8. A 10 kg block is resting on a frictionless surface. A force of 50 N is applied. What is the acceleration of the block? **(PP)**

Working and Answer:
Using $F = ma : 50 = 10a, a = \dfrac{50}{10} = 5\,\text{m/s}^2$. Acceleration $a = 5\,\text{m/s}^2$.

9. A cyclist accelerates from rest to a speed of 12 m/s in 4 s. Calculate the distance covered during this time. **(PP)**

Working and Answer:
Using $s = ut + \frac{1}{2}at$, where $u = 0, a = \frac{12}{4} = 3\,\text{m/s}^2 : s = 0 \cdot 4 + \frac{1}{2}(3)(4^2) = \frac{1}{2}(3)(16) = 24\,\text{m}$. Distance covered $s = 24\,\text{m}$.

10. A stone is thrown horizontally from a height of 45 m. Calculate the time it takes to hit the ground. (Use $g = 9.81\,\text{m/s}^2$) **(PP)**

Working and Answer:
Using $h = \frac{1}{2}gt^2 : 45 = \frac{1}{2}(9.81)t^2, 45 = 4.905t^2, t^2 = \frac{45}{4.905} \approx 9.16, t \approx 3.02\,\text{s}$. Time to hit the ground $t \approx 3.02\,\text{s}$.

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

Working and Answer:
Using $PE = \frac{1}{2}kx^2 : PE = \frac{1}{2}(300)(0.1^2) = \frac{1}{2}(300)(0.01) =$
1.5 J. Potential energy $PE = 1.5\,\text{J}$.

12. A 4 kg object is moving in a circular path of radius 2 m with a speed of 6 m/s. Calculate the centripetal force acting on the object. **(PPP)**

Working and Answer:
Using $F_c = \frac{mv^2}{r} : F_c = \frac{4(6^2)}{2} = \frac{4 \cdot 36}{2} = 72\,\text{N}$. Centripetal force $F_c = 72\,\text{N}$.

13. A 10 kg object is moving with a velocity of 5 m/s. Calculate its kinetic energy. **(PPP)**

Working and Answer:
Using $KE = \frac{1}{2}mv^2 : KE = \frac{1}{2}(10)(5^2) = \frac{1}{2}(10)(25) =$
125 J. Kinetic energy $KE = 125$ J.

14. A 3 kg object is moving in a straight line and comes to a stop after 4 s due to a constant force. If the initial velocity was 12 m/s, calculate the magnitude of the force acting on the object. **(PPP)**

Working and Answer:
Using $F = ma$, first find acceleration $a : v = u + at \Rightarrow 0 = 12 + a(4), a =$
$-3\,\text{m/s}^2. F = 3(-3) = -9\,\text{N} \Rightarrow$ Magnitude $|F| = 9$ N.

15. A 5 kg object is attached to a spring and compressed by 0.2 m. If the spring constant is 250 N/m, calculate the force exerted by the spring. **(PPP)**

Working and Answer:
Using Hooke's Law $F = kx$: $F = 250 \times 0.2 =$ 50 N. Force exerted by the spring $F = 50$ N.

16. A 2 kg mass is moving in a circular path with a radius of 1.5 m at a speed of 4 m/s. Calculate the centripetal acceleration. **(PPP)**

Working and Answer:
Using $a_c = \dfrac{v^2}{r}$: $a_c = \dfrac{4^2}{1.5} = \dfrac{16}{1.5} \approx 10.67\,\text{m/s}^2$. Centripetal acceleration $a_c \approx 10.67\,\text{m/s}^2$.

17. A 1.5 kg object is moving with a velocity of 10 m/s and collides elastically with a stationary 1.5 kg object. Calculate the final velocities of both objects after the collision. **(PPPP)**

Working and Answer:
Using conservation of momentum and kinetic energy: $m_1 = m_2 = 1.5\,\text{kg}, u_1 = 10\,\text{m/s}, u_2 = 0 : v_1 = \dfrac{(m_1 - m_2)u_1 + 2m_2u_2}{m_1 + m_2} = \dfrac{(1.5 - 1.5)(10) + 2(1.5)(0)}{1.5 + 1.5} = 0\,\text{m/s}. v_2 = \dfrac{(m_2 - m_1)u_2 + 2m_1u_1}{m_1 + m_2} = \dfrac{(1.5 - 1.5)(0) + 2(1.5)(10)}{1.5 + 1.5} = 10\,\text{m/s}$. Final velocities: $v_1 = 0\,\text{m/s}, v_2 = 10\,\text{m/s}$.

18. A 3 kg object is moving in a circular path of radius 4 m with a speed of 8 m/s. Calculate the work done by the centripetal force over one complete revolution. **(PPPP)**

Working and Answer:
Centripetal force does no work as it acts perpendicular to the displacement. Work done $W = 0$ J.

19. A 2 kg block slides down a frictionless incline of height 5 m. Calculate the speed of the block at the bottom of the incline. **(PPPP)**

Working and Answer:
Using conservation of energy: $PE_{top} = KE_{bottom} : mgh = \frac{1}{2}mv^2, 2 \cdot 9.81 \cdot 5 = \frac{1}{2}(2)v^2, 98.1 = v^2, v = \sqrt{98.1} \approx 9.9$ m/s. Speed at the bottom $v \approx 9.9$ m/s.

20. A 1 kg mass is attached to a spring with a spring constant of 200 N/m and is compressed by 0.3 m. Calculate the maximum speed of the mass when released. **(PPPP)**

Working and Answer:
Using conservation of energy: $PE_{spring} = KE_{max} : \frac{1}{2}kx^2 = \frac{1}{2}mv^2, \frac{1}{2}(200)(0.3^2) = \frac{1}{2}(1)v^2, 9 = \frac{1}{2}(1)v^2, v^2 = 18, v = \sqrt{18} \approx 4.24$ m/s. Maximum speed $v \approx 4.24$ m/s.

21. A 5 kg object is moving in a circular path with a radius of 3 m at a speed of 10 m/s. Calculate the work done by the centripetal force over one complete revolution. **(PPPP)**

Working and Answer:
Centripetal force does no work as it acts perpendicular to the displacement. Work done $W = 0$ J.

22. A 4 kg object is moving with a velocity of 6 m/s and collides elastically with a stationary 4 kg object. Calculate the final velocities of both objects after the collision. **(PPPPP)**

Working and Answer:
Using conservation of momentum and kinetic energy: $m_1 = m_2 = 4\,\text{kg}, u_1 = 6\,\text{m/s}, u_2 = 0 : v_1 = \dfrac{(m_1 - m_2)u_1 + 2m_2u_2}{m_1 + m_2} = \dfrac{(4-4)(6) + 2(4)(0)}{4+4} = 0\,\text{m/s}. v_2 = \dfrac{(m_2 - m_1)u_2 + 2m_1u_1}{m_1 + m_2} = \dfrac{(4-4)(0) + 2(4)(6)}{4+4} = 6\,\text{m/s}$. Final velocities: $v_1 = 0\,\text{m/s}, v_2 = 6\,\text{m/s}$.

23. A 2 kg mass is attached to a spring with a spring constant of 150 N/m and is compressed by 0.4 m. Calculate the maximum speed of the mass when released. **(PPPPP)**

Working and Answer:
Using conservation of energy: $PE_{spring} = KE_{max} : \frac{1}{2}kx^2 = \frac{1}{2}mv^2, \frac{1}{2}(150)(0.4^2) = \frac{1}{2}(2)v^2, 12 = v^2, v = \sqrt{12} \approx 3.46\,\text{m/s}$. Maximum speed $v \approx 3.46\,\text{m/s}$.

24. A 3 kg object is moving in a circular path of radius 2 m with a speed of 5 m/s. Calculate the work done by the centripetal force over one complete revolution. **(PPPPP)**

Working and Answer:
Centripetal force does no work as it acts perpendicular to the displacement. Work done $W = 0$}