Forces in Action Questions – OCR A Level Physics

Praneel Physics

1. A 5 kg block rests on a horizontal surface. Calculate the normal force acting on it. **(P)**

Working and Answer:

$$F_N = mg = 5 \times 9.8 = 49 \text{ N}$$

Answer: 49 N

2. A 10 kg object is suspended from a rope. Calculate the tension in the rope. **(P)**

Working and Answer:

$$T = mg = 10 \times 9.8 = 98 \text{ N}$$

Answer: 98 N

3. A 3 kg box is pulled with a force of 15 N horizontally on a frictionless surface. Find the acceleration. **(P)**

Working and Answer:

$$a = \frac{F}{m} = \frac{15}{3} = 5 \text{ m/s}^2$$

Answer: 5 m/s^2

4. A 6 kg block rests on a surface with coefficient of static friction 0.4. Find maximum friction force. **(PP)**

Working and Answer:

$$F_N = mg = 6 \times 9.8 = 58.8 \text{ N}$$

$$F_{\text{friction, max}} = \mu_s F_N = 0.4 \times 58.8 = 23.52 \text{ N}$$

Answer: 23.5 N

5. A 12 kg block is pulled at 20° above horizontal with 50 N force on a frictionless surface. Find horizontal acceleration. **(PP)**

Working and Answer:

$$F_x = 50\cos 20^\circ = 50 \times 0.94 = 47 \text{ N}$$

$$a = \frac{F_x}{m} = \frac{47}{12} = 3.92 \text{ m/s}^2$$

Answer: 3.92 m/s^2

6. A 10 kg box is on a 30° slope. Calculate the component of weight parallel to the slope. **(PP)**

Working and Answer:

$$F_{\parallel} = mg\sin\theta = 10 \times 9.8 \times \sin 30^\circ = 49 \text{ N}$$

Answer: 49 N

7. A 15 kg crate is pulled up a 25° slope with coefficient of kinetic friction 0.2. Calculate minimum force to move it at constant speed. **(PPP)**

Working and Answer:

$$F_{\text{gravity parallel}} = mg\sin 25^\circ = 15 \times 9.8 \times 0.4226 = 62.1 \text{ N}$$

$$F_N = mg\cos 25^\circ = 15 \times 9.8 \times 0.9063 = 133.2 \text{ N}$$

$$F_{\text{friction}} = \mu_k F_N = 0.2 \times 133.2 = 26.64 \text{ N}$$

$$F_{\text{total}} = F_{\text{gravity parallel}} + F_{\text{friction}} = 62.1 + 26.64 = 88.74 \text{ N}$$

Answer: 88.7 N

8. A 3 kg block connected to a 5 kg hanging mass over a frictionless pulley. Find acceleration of the system. **(PPP)**

Working and Answer:

For $m_1 = 3$ kg (block), $m_2 = 5$ kg (hanging) :

$$m_2 g - T = m_2 a$$

$$T - m_1 a = m_1 a$$

Adding: $m_2 g = (m_1 + m_2)a \Rightarrow a = \dfrac{m_2 g}{m_1 + m_2} = \dfrac{5 \times 9.8}{8} = 6.13 \text{ m/s}^2$

Answer: 6.13 m/s^2

9. A uniform beam of length 4 m and weight 200 N is supported at both ends. A 300 N weight is placed 1 m from the left end. Calculate the reaction forces at the supports. **(PPP)**

Working and Answer:

Taking moments about left support:

$$R_2 \times 4 = 300 \times 1 + 200 \times 2$$

$$R_2 = \frac{300 + 400}{4} = 175 \text{ N}$$

Sum of vertical forces: $R_1 + R_2 = 300 + 200 = 500$

$$R_1 = 500 - 175 = 325 \text{ N}$$

Answer: Left support: 325 N, Right support: 175 N

10. A ladder of weight 400 N rests against a smooth vertical wall making an angle of 60° with the ground. Calculate the normal force at the base. **(PPP)**

Working and Answer:

Taking moments about the base:

$$N_{\text{wall}} \times h = 400 \times \frac{L}{2} \cos 60^\circ$$

$$N_{\text{wall}} = \frac{400 \times \frac{L}{2} \times 0.5}{h}$$

Since $h = L \sin 60^\circ = L \times 0.866$

$$N_{\text{wall}} = \frac{400 \times 0.5 \times L/2}{0.866L} = 115.5 \text{ N}$$

Answer: 115.5 N

11. A 10 kg block is pulled with 60 N force at 30° to horizontal. Coefficient of kinetic friction is 0.25. Calculate acceleration. **(PPPP)**

Working and Answer:

$$F_x = 60\cos 30^\circ = 60 \times 0.866 = 51.96 \text{ N}$$

$$F_y = 60\sin 30^\circ = 60 \times 0.5 = 30 \text{ N}$$

$$F_N = mg - F_y = 10 \times 9.8 - 30 = 98 - 30 = 68 \text{ N}$$

$$F_{\text{friction}} = \mu_k F_N = 0.25 \times 68 = 17 \text{ N}$$

$$F_{\text{net}} = F_x - F_{\text{friction}} = 51.96 - 17 = 34.96 \text{ N}$$

$$a = \frac{F_{\text{net}}}{m} = \frac{34.96}{10} = 3.5 \text{ m/s}^2$$

Answer: 3.5 m/s^2

12. Two blocks, 4 kg and 6 kg, connected by a light string on a frictionless surface. The 6 kg block is pulled by 30 N. Find acceleration and tension. **(PPPP)**

Working and Answer:

$$m_{\text{total}} = 4 + 6 = 10 \text{ kg}$$

$$a = \frac{F}{m_{\text{total}}} = \frac{30}{10} = 3 \text{ m/s}^2$$

$$T = m_1 a = 4 \times 3 = 12 \text{ N}$$

Answer: Acceleration = 3 m/s^2, Tension = 12 N

13. A car of mass 1200 kg accelerates from rest at 3 m/s^2 on a horizontal road. Calculate resultant horizontal force and frictional force if engine force is 5000 N. **(PPPP)**

Working and Answer:

$$F_{\text{resultant}} = ma = 1200 \times 3 = 3600 \text{ N}$$

$$F_{\text{friction}} = F_{\text{engine}} - F_{\text{resultant}} = 5000 - 3600 = 1400 \text{ N}$$

Answer: Resultant force = 3600 N, Frictional force = 1400 N

14. A 20 kg box rests on a rough 40° incline. The coefficient of static friction is 0.5. Find if the box will slide. **(PPPP)**

Working and Answer:

$$F_{\parallel} = mg\sin 40^\circ = 20 \times 9.8 \times 0.6428 = 126 \text{ N}$$

$$F_N = mg\cos 40^\circ = 20 \times 9.8 \times 0.7660 = 150 \text{ N}$$

$$F_{\text{friction max}} = \mu_s F_N = 0.5 \times 150 = 75 \text{ N}$$

Since $F_{\parallel} > F_{\text{friction max}}$, box will slide down

Answer: Yes, it will slide

15. A particle moves in a circle of radius 2 m with speed 5 m/s. Calculate centripetal force if mass is 0.5 kg. **(PPPP)**

Working and Answer:

$$F_c = \frac{mv^2}{r} = \frac{0.5 \times 5^2}{2} = \frac{0.5 \times 25}{2} = 6.25 \text{ N}$$

Answer: 6.25 N

16. Two blocks of masses 8 kg and 3 kg connected over a pulley. Coefficient of kinetic friction between 8 kg block and surface is 0.3. Find acceleration. **(PPPP)**

Working and Answer:

$$m_1 = 8, m_2 = 3, \mu_k = 0.3$$

$$F_f = \mu_k m_1 g = 0.3 \times 8 \times 9.8 = 23.52 \text{ N}$$

$$\text{Net force} = m_2 g - F_f = 3 \times 9.8 - 23.52 = 29.4 - 23.52 = 5.88 \text{ N}$$

$$a = \frac{\text{Net force}}{m_1 + m_2} = \frac{5.88}{11} = 0.535 \text{ m/s}^2$$

Answer: 0.54 m/s^2

17. A uniform plank 6 m long rests on two supports 2 m from each end. A 300 N weight is placed 1 m from the left end. Find the reaction forces. **(PPPP)**

Working and Answer:

Distance between supports $= 6 - 2 - 2 = 2$ m

Taking moments about left support:

$$R_2 \times 4 = 300 \times 1 + W \times 3$$

Let $W =$ weight of plank, assume uniform $= mg$

Sum forces: $R_1 + R_2 = W + 300$

Answer: Requires plank weight, cannot solve without it

18. A 2 kg mass is attached to a spring of spring constant 500 N/m. It is stretched 0.1 m and released. Calculate the maximum acceleration of the mass. **(PPPP)**

Working and Answer:

$$F_{\max} = kx = 500 \times 0.1 = 50 \text{ N}$$

$$a_{\max} = \frac{F_{\max}}{m} = \frac{50}{2} = 25 \text{ m/s}^2$$

Answer: 25 m/s^2

19. A sphere of mass 0.1 kg is dropped from height 5 m. Find velocity just before impact and impact force if stopped over 0.01 m. **(PPPP)**

Working and Answer:

$$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 5} = 9.9 \text{ m/s}$$

$$a = \frac{v^2}{2s} = \frac{9.9^2}{2 \times 0.01} = \frac{98.01}{0.02} = 4900.5 \text{ m/s}^2$$

$$F = ma = 0.1 \times 4900.5 = 490.05 \text{ N}$$

Answer: Velocity = 9.9 m/s, Impact force $\approx$ 490 N

20. A particle moves in a vertical circle of radius 2 m. Calculate the minimum speed at the top of the circle to maintain tension in the string. **(PPPP)**

Working and Answer:

At minimum speed, tension $T = 0$

$$mg = \frac{mv^2}{r} \Rightarrow v = \sqrt{rg} = \sqrt{2 \times 9.8} = 4.43 \text{ m/s}$$

Answer: 4.43 m/s

21. A 1000 kg car rounds a curve of radius 50 m at 20 m/s. Calculate friction force assuming no slipping. **(PPPP)**

Working and Answer:

$$F_c = \frac{mv^2}{r} = \frac{1000 \times 20^2}{50} = \frac{1000 \times 400}{50} = 8000 \text{ N}$$

Answer: 8000 N