eClassroom

Dynamics of a Particle

Worked Solutions

Suitable for:

Pearson Edexcel International A-Level (iAL) — Mechanics 1

Question 1 — Worked Solution

$$F = ma \Rightarrow 20 = 5a$$

$$\therefore a = 4 \text{ m s}^{-2}$$

Question 2 — Worked Solution

Find acceleration using suvat: u=0, v=24, t=8

$$a = \frac{v-u}{t} = \frac{24}{8} = 3 \text{ m s}^{-2}$$

Apply Newton's second law (net force = ma):

$$F - R = ma \Rightarrow F - 400 = 1200 \times 3 = 3600$$

$$\therefore F = 4000 \text{ N}$$

Question 3 — Worked Solution

(a)

Weight W = mg = 2×9.8 = 19.6 N acting downward.

Normal reaction R = 19.6 N acting upward from the table.

(b)

By Newton's third law, the book exerts an equal and opposite force on the table.

Force = 19.6 N acting vertically downward on the table.

Question 4 — Worked Solution

Taking upward as positive. Lift accelerates upward ⇒ net upward force.

$$R - mg = ma$$

$$R = m(g + a) = 70 \times (9.8 + 1.5) = 70 \times 11.3$$

$$\therefore R = 791 \text{ N}$$

Question 5 — Worked Solution

(a)

Lift moves upward and decelerates ⇒ acceleration is downward (negative if up is positive).

$$R - mg = m(-a) = -ma$$

$$R = m(g - a) = 5 \times (9.8 - 2) = 5 \times 7.8$$

$$\therefore R = 39 \text{ N}$$

(b)

Weight = mg = 5×9.8 = 49 N.

R = 39 N < Weight = 49 N. The normal reaction is less than the weight because the acceleration is downward.

Question 6 — Worked Solution

(a)

Let upward be positive. Apply Newton's second law to the person:

$$R - mg = ma \Rightarrow 1000 - 80 \times 9.8 = 80a$$

$$1000 - 784 = 80a \Rightarrow 216 = 80a$$

$$\therefore a = 2.7 \text{ m s}^{-2}$$

(b)

Since a is positive (upward), the net force is upward.

The lift is accelerating upward (or decelerating while moving downward).

Question 7 — Worked Solution

(a)

Treating truck and trailer as one system (total mass = 2800 kg):

$$F = (m_1 + m_2)a \Rightarrow 2800 = 2800\,a$$

$$\therefore a = 1 \text{ m s}^{-2}$$

(b)

Consider the trailer alone. The only horizontal force is the tension T:

$$T = m_{\text{trailer}} \times a = 800 \times 1$$

$$\therefore T = 800 \text{ N}$$

Question 8 — Worked Solution

(a)

Total mass = 4000 kg. Net force = 6000 – 500 – 200 = 5300 N.

$$a = \frac{5300}{4000} = \frac{53}{40}$$

$$\therefore a = 1.325 \text{ m s}^{-2}$$

(b)

Consider caravan alone. T forwards, resistance 200 N backwards:

$$T - 200 = 1000 \times 1.325$$

$$\therefore T = 1525 \text{ N}$$

Question 9 — Worked Solution

(a)

Total mass = 4000 kg. Braking force = 8000 N (opposing motion):

$$a = \frac{8000}{4000} = 2 \text{ m s}^{-2} \text{ (deceleration)}$$

(b)

Consider trailer alone. The braking force does NOT act directly on the trailer — the truck's brakes slow the truck, which pushes back on the trailer via the towbar (compression).

Equation of motion for trailer (decelerating at 2 m s^{-2}):

$$-T_{\text{thrust}} = m_{\text{trailer}} \times (-a)$$

$$T = 1500 \times 2 = 3000 \text{ N}$$

The force in the towbar is 3000 N. The towbar is in compression (the truck pushes back on the trailer).

Question 10 — Worked Solution

(a)

Resolving along the plane (positive down the slope):

$$mg\sin 30° = ma$$

$$a = g\sin 30° = 9.8 \times 0.5$$

$$\therefore a = 4.9 \text{ m s}^{-2}$$

(b)

Resolving perpendicular to the plane:

$$N = mg\cos 30° = 5 \times 9.8 \times \frac{\sqrt{3}}{2}$$

$$\therefore N = 42.4 \text{ N (3 s.f.)}$$

Question 11 — Worked Solution

Resolving along the plane (positive up the slope):

$$F - mg\sin 25° = ma$$

$$40 - 4 \times 9.8 \times \sin 25° = 4a$$

$$40 - 16.5666 = 4a$$

$$23.4334 = 4a$$

$$\therefore a = 5.858 \approx 5.86 \text{ m s}^{-2}$$

Question 12 — Worked Solution

(a)

For A (on table): T = 3a ...(1)

For B (hanging): 2g – T = 2a ...(2)

(1)+(2): 2g = 5a

$$a = \frac{2g}{5} = \frac{2 \times 9.8}{5}$$

$$\therefore a = 3.92 \text{ m s}^{-2}$$

(b)

$$T = 3a = 3 \times 3.92$$

$$\therefore T = 11.76 \text{ N}$$

Question 13 — Worked Solution

(a)

For A (5 kg, descends): 5g – T = 5a ...(1)

For B (3 kg, ascends): T – 3g = 3a ...(2)

(1)+(2): 2g = 8a

$$a = \frac{g}{4} = \frac{9.8}{4}$$

$$\therefore a = 2.45 \text{ m s}^{-2}$$

(b)

$$T = 3(g + a) = 3 \times (9.8 + 2.45) = 3 \times 12.25$$

$$\therefore T = 36.75 \text{ N}$$

(c)

$$s = \frac{1}{2}at^2 = \frac{1}{2} \times 2.45 \times 4$$

$$\therefore s = 4.9 \text{ m}$$

Question 14 — Worked Solution

(a)

B (5 kg) is heavier than A projected up slope. B descends, A moves up slope.

For A (up slope): T – mg sin30° = ma ...(1)

For B (descending): mg – T = ma ...(2)

(1)+(2): m_B g – m_A g sin30° = (m_A + m_B)a

$$5 \times 9.8 - 2 \times 9.8 \times 0.5 = 7a$$

$$49 - 9.8 = 7a \Rightarrow 39.2 = 7a$$

$$\therefore a = \frac{39.2}{7} = 5.6 \text{ m s}^{-2}$$

(b)

$$T = m_B(g - a) = 5 \times (9.8 - 5.6) = 5 \times 4.2$$

$$\therefore T = 21 \text{ N}$$

Question 15 — Worked Solution

Total mass = 500+300 = 800 kg.

(a) Constant speed

$$T = mg = 800 \times 9.8$$

$$\therefore T = 7840 \text{ N}$$

(b) Accelerating upward at 0.8 m s^{-2}

$$T - mg = ma \Rightarrow T = m(g + a) = 800 \times (9.8 + 0.8) = 800 \times 10.6$$

$$\therefore T = 8480 \text{ N}$$

(c) Decelerating at 1.2 m s^{-2} while moving upward

Deceleration while moving up ⇒ acceleration is downward.

$$T - mg = m(-a) \Rightarrow T = m(g - a) = 800 \times (9.8 - 1.2) = 800 \times 8.6$$

$$\therefore T = 6880 \text{ N}$$

Question 16 — Worked Solution

(a)

Total mass = 4500 kg. Net force = 9000 – 1500 = 7500 N.

$$a = \frac{7500}{4500} = \frac{5}{3}$$

$$\therefore a = \frac{5}{3} \approx 1.67 \text{ m s}^{-2}$$

(b)

Consider trailer alone: $T - R_t = m_t a$

$$T - 500 = 1500 \times \frac{5}{3} = 2500$$

$$\therefore T = 3000 \text{ N}$$

(c)

After break: truck alone, F = 9000 N, R = 1000 N, mass = 3000 kg.

$$a = \frac{9000 - 1000}{3000} = \frac{8000}{3000} = \frac{8}{3}$$

$$\therefore a = \frac{8}{3} \approx 2.67 \text{ m s}^{-2}$$