7 Introduction to mechanics

Pages 128–131 Exam practice questions

1 C

2 B

3 D

4 B

5 A

6 A

7 B

8 B

9 C

10 A

11

Quantity	Fundamental SI units	Type of quantity
Kinetic energy	kg m^2 s^{-2}	scalar
Acceleration	m s^{-2}	vector
Displacement	m	vector
Power	kg m^2 s^{-3}	scalar

12 a) 320 N × 0.54 m – 780 N × 0.18 m = R_3 × 0.27 m

$\Rightarrow R_3$ = 120 N

b) R_2 = 780 N – 120 N – 320 N

= 340 N

13 a) Moment = 16 000 N × 1.5 m + 8 000 N × 0.75 m

= 30 000 N m

b) i) The principle of moments states that when a body is in equilibrium, the moments acting on it balance.

ii) 30 000 N m = R_1 × 3 m

R_1 = 10 000 N and R_2 = 14 000 N

c) R_1 and R_2 are the same at 8 000 N.

14 a) Stable equilibrium is produced, as the centre of gravity lies below the pivot.

b) W = 0.35 kg × 9.8 N kg^{-1}

= 3.4 N

c) 3.4 N × x = 5.4 N × 28 cm

x = 44.5 cm from the left of the pivot.

d) i) V_v = 45 sin 40 m s^{-1}

= 30 m s^{-1}

ii) $V_h = 45 \cos 40 \text{ m s}^{-1}$

$= 34 \text{ m s}^{-1}$

e) $s = V_h \times t$

$= 34 \text{ m s}^{-1} \times 5.9 \text{ s}$

= 200 m (2 s.f.)

15 a) $T \sin 20 = 7.4$ N

$$T = \frac{7.4 \text{ N}}{\sin 20}$$

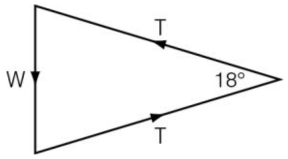
= 22 N (2 s.f.)

b) $L = W + T \cos \theta$

= 1.7 N + 22 N cos 20

= 22 N (2 sig figs)

16 a)



b) $W = 2T \sin 9^0$

$$T = \frac{W}{2 \sin 9^0}$$

= 43 kN

17 a) 8 N each

b) Taking moments about B

40 N × 15 cm + 16 N × 50 cm = R_2 × 100 cm

$$R_2 = \frac{600 \text{ N cm} + 800 \text{ N cm}}{100 \text{ cm}}$$

= 14 N

R_1 = 40 N + 16 N – 14 N

= 42 N

c) i) Taking moments about B

40 N × d = 16 N × 50 cm

$$d = \frac{800 \text{ N cm}}{40 \text{ N}}$$

= 20 cm (1)

ii) $R_2 = 0$

Taking moments about B

40 N × 25 cm = F × 50 cm

$$F = \frac{1\,000\text{ N cm}}{50\text{ cm}}$$

= 20 N

So the extra weight to be added = 20 N – 16 N = 4N

18 a) 20 N × 9 cm = F_R × 18 cm

F_R = 10 N

b) i) W × 15 cm = 10 N × 3 cm

W = 2 N

ii) R = 10 N – 2 N

= 8 N downwards

c) When you move the pedal, point A moves twice as far.

When R lifts the lid, the far end moves 10 times as far.

(In total the distance is multiplied by 20.)

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19 a) i) Let the radius of the of wheel be r:

The anticlockwise turning moment from B = 800r.

The clockwise turning moment from A = 1600r sin(300) = 800r.

So the wheel is balanced (unstable equilibrium), no force is needed at C.

ii) The anticlockwise turning moment from B = 800r sin(30^0) = 400r.

The clockwise turning moment from A = 1600r.

To prevent rotation a vertical downwards force must be applied at C, which applies a moment of 1200r.

So, 1200r = Fr cos(30^0)

F = 1390 N

b) The wheel is in stable equilibrium when it has been rotated by 180^0. The force required to prevent rotation at C is zero, but now the centre of gravity of the wheel is below the point of rotation.

c) In the position shown in figure 7.43, the only position in which people can be added, without causing rotation is in the seats below point O. Let us assign them weight W.

If the wheel is now rotated clockwise through 90^0, the wheel will still balance.

So, because the weight at B provides no turning moment:

$Wr = 1600r\cos(30^0)$

$W = 1390$ N

20 Assume the beam has a length L.

Taking moments about the hinge:

$MgL = T(L/2)\cos(60^o)$

$T = 4Mg$

The vertical component of $T = 4Mg\cos(60^0) = 2Mg$

The horizontal component of $T = 4Mg\sin(60^0) = 2\sqrt{3}Mg$

So the hinge exerts a force on the beam of Mg vertically downwards and $2\sqrt{3}Mg$ horizontally.

The resultant force on the beam from the hinge is:

$\sqrt{13}Mg$ at an angle θ to the beam, where $\tan\theta = 1/(2\sqrt{3})$. The force on the hinge is equal and opposite to this.