Unit 4

Answers: Dynamics

Quick checks

1 **c**

2 **c**

3 **c** $50 \times 3 + 150v = 0 \quad v = -1$

4 **c**

5 **b** **resultant**

6 **c**

7 **c**

8 **b** $0.25 \times 80 = 20$

$20 \div 0.50 = 40$

9 **b** $\tau = 30 \times 0.40 = 12$

10 **c**

11 **b**

12 **b** $\theta = \tan^{-1} 0.5 = 26.6^\circ \approx 27^\circ$ $\tan^{-1} 0.58$ $\mu = 1$

13 **a**

14 **c**

15 **a**

16 **c** $|\vec{F}| = \sqrt{6^2 + 8^2} = 10 \qquad m = F/a = 10/1 = 10$

17 **a**

18 **b** $\vec{F} = 30\hat{i} - 18\hat{j} \qquad \vec{a} = \vec{F}/6 = 5\hat{i} - 3\hat{j}$

19 **a**

20 **b** $6t = 1 \times 30 \quad t = 5 \qquad a = 6 \qquad t = 30/6 = 5$

21 **b**

22 **b**

23 **a** $R = m(g + a) = 60 \times (10 + 2) = 720$

24 **c** $u\cos 30^\circ$ $u\cos 30^\circ$ $u\sin 30^\circ$ $\Delta p = 2mu\cos 30^\circ$ $2mu\cos 30^\circ/t$

25 **a**

26 **a** $a = \dfrac{(m_1 - m_2)g}{m_1 + m_2} = \dfrac{(12 - 8) \times 10}{20} = 2$

27 **a** $\tan\theta = \mu \qquad \theta = \tan^{-1}\mu$

28 **b** $= \mu mg = 0.5 \times 10 \times 10 = 50 \qquad = 100 - 50 = 50$ $a = 50/10 = 5$

29 **c** $= \mu R = \mu mg\cos 30^\circ = 0.7 \times 2 \times 9.8 \times 0.866 = 11.9$ $mg\sin 30^\circ = 9.8$ $\tan 30^\circ = 0.58 < 0.7$

30 **c** $mg\sin\theta \qquad a = g\sin 30^\circ = 10 \times 0.5 = 5$

31 **a**

21.

a force is that which changes, or tends to change, a body's state of rest or of uniform motion in a straight line.

inertia

22.

$$\vec{F}\Delta t = m\vec{v} - m\vec{u}$$

$$\vec{F} = \frac{m\vec{v} - m\vec{u}}{\Delta t}$$

Δt $\vec{F}\Delta t = m\vec{v} - m\vec{u}$

$F =$ $\Delta p/\Delta t$

23. $F = 0$ $m(v-u)/t = 0$ $v = u$

$F = kma$ $k = 1$ $1 =$ $k \times 1 \times 1$ $k = 1$ $F = ma$

$a = \dfrac{0-8}{2} = -4$ $F = ma = 2 \times (-4) = -8$ **8 N**

$F \times 2 = 2 \times 8$

24. **couple**

$2r = 1.0$

$\tau = 100 \times 1.0 = 100$ $30^\circ = \pi/6$

$$W = \tau\theta = 100 \times \frac{\pi}{6} = \mathbf{52.4}$$

$2r$ $r\theta$ $2Fr\theta$

25.

$$\tan\lambda = F/R = \mu$$

$$F = mg\sin\theta \qquad R = mg\cos\theta \qquad \tan\theta = F/R = \mu$$

$$\lambda = \theta$$

$$a = -\mu g \qquad v^2 = u^2 + 2as \;\; 0 = 14^2 - 2\mu g \times 40$$

$$\mu = \frac{196}{2 \times 9.8 \times 40} = \frac{196}{784} = \mathbf{0.25}$$

26.

$$10 \times 10 + 30 \times 30 + 50 \times 50 + 70 \times 70 + 90 \times 90 + 100 \times 50$$

$$= 100 + 900 + 2500 + 4900 + 8100 + 5000 = 21\,500$$

$$= 10 + 30 + 50 + 70 + 90 + 100 = 350$$

$$x = \frac{21\,500}{350} = \mathbf{61.4}$$

27.

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2 \qquad F_{12} = -F_{21}$$

$$m = \frac{W}{g} = \frac{2400}{9.8} = 244.9 \qquad F = ma = 244.9 \times 12.0 = \mathbf{2940\ N}$$

$$F = 2940 + 60 = \mathbf{3000\ N}$$

28. **Impulse** $\vec{F}\Delta t$

$= \frac{1}{2} \times 2 \times 20 + 4 \times 20 + \frac{1}{2} \times 4 \times 20 = 20 + 80 + 40 =$ **140 N s**

$a = F/m = 20/2 =$ **10 m/s²**

29. **angle of friction**

angle of repose

$\tan = \mu$

$a = g(\sin 30^\circ - 0.2 \cos 30^\circ) = 9.8 \times (0.5 - 0.173) = 9.8 \times 0.327 = 3.20$

$v = at = 3.20 \times 5 =$ **16.0 m/s** $a = 3.27$ $v = 16.3$

$v = 3.20 \times 6 =$ **19.2 m/s**

30. $a = F/m = 10/7 =$ **1.43 m/s²**

$v^2 = u^2 + 2as = 16 + 2 \times 1.43 \times 3 = 16 + 8.57 = 24.57$ $v =$ **4.96 m/s**

31. $a = g(\sin 45^\circ - \mu \cos 45^\circ) = 9.8 \times 0.707 \times (1 - 0.3) = 9.8 \times 0.495 =$ **4.85 m/s²**

32. $\theta = \tan^{-1} 0.30 =$ **16.7°**

$mg \sin 30^\circ = 0.15 \times 9.8 \times 0.5 =$ 0.735

$\mu mg \cos 30^\circ = 0.30 \times 0.15 \times 9.8 \times 0.866 = 0.382$

$0.735 - 0.382 =$ **0.35 N**

33. $a = \dfrac{v^2 - u^2}{2s} = \dfrac{169}{5.6} = 30.2$ $F = ma = 7 \times 30.2 =$ **211 N** 2.1×10^2

34. $m_2 g - T = m_2 a$ $T - \mu m_1 g = m_1 a$

$$a = \frac{m_2 g - \mu m_1 g}{m_1 + m_2} = \frac{5 \times 9.8 - 0.5 \times 5 \times 9.8}{10} = \frac{24.5}{10} = \mathbf{2.45^2}$$

$T = m_2(g - a) = 5 \times (9.8 - 2.45) =$ **36.75 N**

35. $p = mv = 7.30 \times 15.0 = 109.5$

$p \cos 40^\circ = 109.5 \times 0.766 =$ **83.9 kg m/s** $p \sin 40^\circ = 109.5 \times 0.643 =$ **70.4 kg m/s**

36. $70.0 \times 2.00 + 65.0 \times (-2.50) = (70.0 + 65.0)v$ $140 - 162.5 = 135v$ $v = -0.167$ **0.167 m/s to the left**

37. $= \frac{350}{2} = 175 \qquad t = \dfrac{0.130}{175} = 7.4 \times 10^{-4}\ \mathbf{s}$

$$F = \frac{\Delta p}{t} = \frac{1.80 \times 10^{-3} \times 350}{7.43 \times 10^{-4}} = \mathbf{848\ N}$$

38. $R = \sqrt{270^2 + 300^2 + 2 \times 270 \times 300 \cos 60^\circ} = \sqrt{72\,900 + 90\,000 + 81\,000} = \sqrt{243\,900} = \mathbf{494\ N}$

$$\tan\alpha = \frac{300 \sin 60^\circ}{270 + 300 \cos 60^\circ} = \frac{259.8}{420} = 0.619 \qquad \alpha = \mathbf{31.7°}$$

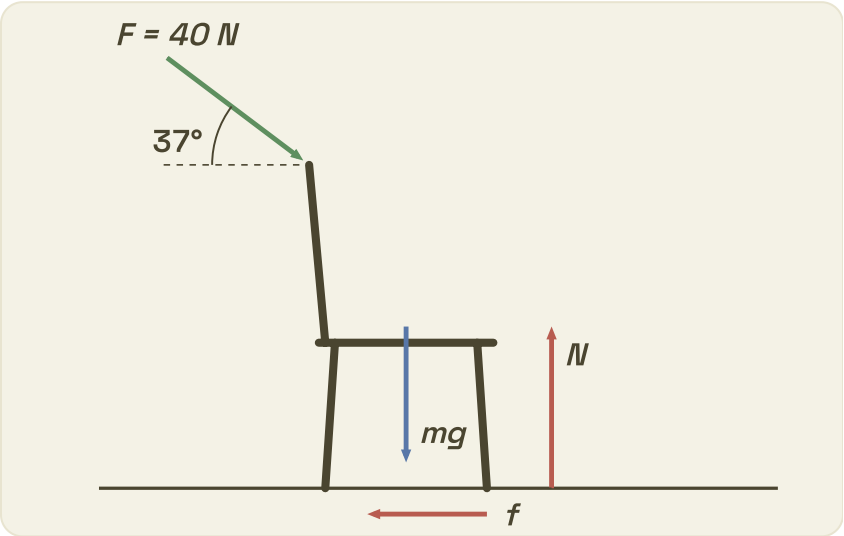
39. $a = 0.250/0.160 = 1.5625$

$x = \frac{1}{2}at^2 = \frac{1}{2} \times 1.5625 \times 4 = \mathbf{3.13\ m}$ $v = at = \mathbf{3.13\ m/s}$

$$x = 3.125 + 3.125 \times 3 = 12.5$$

$x = 12.5 + 3.125 \times 2 + \frac{1}{2} \times 1.5625 \times 4 = 12.5 + 6.25 + 3.125 = \mathbf{21.9\ m}$ $v = 3.125 + 1.5625 \times 2 = \mathbf{6.25\ m/s}$

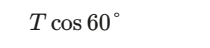
40. mg N $F = 40.0$ f



$$N = mg + F \sin 37^\circ = 12.0 \times 9.8 + 40.0 \times 0.602 = 117.6 + 24.1 = \mathbf{142\ N}$$

41. $p = 0.145 \times 1.30 + 0.0570 \times (-7.80) = 0.1885 - 0.4446 = -0.256$
0.256 kg m/s in the −y direction

42.

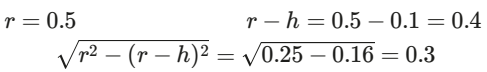


$$T\cos 60^\circ \times 14 = 600 \times 20 \quad \Rightarrow \quad T = \frac{12\,000}{14 \times 0.5} = \mathbf{1714}$$

43. $F = \mu R = 0.015 \times 12\,000 = \mathbf{180\ N}$

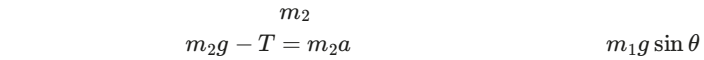
$$P = Fv = 180 \times 20 = 3600 \qquad \mathbf{3.6\ kW}$$

44.



$$F \times 0.4 = 360 \times 0.3 \quad \Rightarrow \quad F = \mathbf{270}$$

45.



$$a = \frac{(m_2 - m_1 \sin\theta)\, g}{m_1 + m_2}$$

$$T = m_2(g - a) = m_2 g \left(1 - \frac{m_2 - m_1 \sin\theta}{m_1 + m_2}\right) = \frac{m_1 m_2\, g\,(1 + \sin\theta)}{m_1 + m_2}$$

$$m_1 = m_2 \ \ a = \frac{(1 - \sin 25^\circ)\, g}{2} = \frac{(1 - 0.423) \times 9.8}{2} = \mathbf{2.83\ m/s^2}$$