

1. (a) Same change of gravitational pe to ke on each track ✓
 So same speeds ✓
- (b) Track (i) has more time at a slow speed initially yet the same final speed, so average speed is less (owtte) ✓
 So (i) is longer time or (ii) is shorter time ✓
- (c) Speed would be the same as in (a) or mass makes no difference (ottwe) ✓
 So (i) is longer time / (ii) is shorter time (same as (b)) ✓

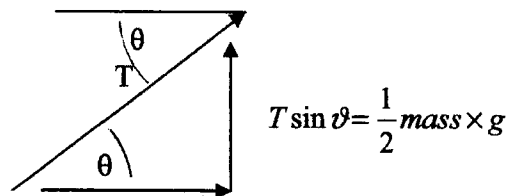
[6]

2. (a) $T_V = 2.00 \times 9.81 = 19.6 \text{ N}$ ✓
- $19.6 = T_{60} \times \sin(60^\circ)$
 $T_{60} = 22.6 \text{ N}$ ✓
- $mg = T_H \times \tan(60^\circ)$
 $T_H = 19.6 / \tan(60^\circ)$
 $= 11.3 \text{ N}$ ✓

- (b) Forces are vectors ✓
 and so must be added taking into account the directions / the forces are represented by arrows whose lengths are proportional to the magnitudes and the directions of the forces form

a right angle triangle ✓

(c)



Factor half ✓
 Eliminate T ✓

$$\frac{1}{2} m_{\text{wire}} g = T \sin \vartheta_{\text{wire}}$$

$$\frac{1}{2} (m_{\text{wire}} + m_{\text{bird}}) = T \sin \vartheta_{\text{wire \& bird}}$$

$$\frac{(m_{\text{wire}} + m_{\text{bird}})}{m_{\text{wire}}} = \frac{\sin \vartheta_{\text{wire \& bird}}}{\sin \vartheta_{\text{wire}}}$$

$$m_{\text{bird}} = 0.8 \text{ kg} \quad \checkmark$$

[8]

3. (a) $Stress = \frac{Force}{Area} = \frac{0.5 \times 70 \times 9.81}{5.0 \times 10^{-4}}$ ✓
 $= 7 \times 10^5 \text{ Nm}^{-2}$ ✓
- (b) $ratio = 0.07$ ecf ✓
- (c) $mass\ of\ giant = 9^3 \times 70$ ✓ (✓)
 $= 5.1 \times 10^4 \text{ kg}$ ✓
- (d) $stress = \frac{0.5 \times 5.1 \times 10^4 \times 9.81}{9^2 \times 5.0 \times 10^4}$ ecf ✓
 $= 6.2 \times 10^6 \text{ Nm}^{-2}$ ✓
 $ratio = 0.6$ ecf ✓
- (e) The ratio will be 1.2 and he will break his leg. owtte ✓

[8]

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4. (a) Simple sketch with peaks at bows of boat and one trough in the middle
 Or peak in the middle and troughs at ends ✓
 18 m ✓
- (b) $c = 4.8 \text{ ms}^{-1}$ ✓
 $f = c/\lambda$ ✓
 $= 4.8(5)/18 = 0.27 \text{ Hz}$ ✓

[5]

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5. (a) $p = \frac{h}{\lambda} = \frac{6.6 \times 10^{-34}}{2 \times 10^{-15}}$ ✓
 $= 3.3 \times 10^{19} \text{ kg ms}^{-1}$ (1 mark if no factor half) ✓
- (b) $E = mc^2$
 $= pc$
- $E = 3.3 \times 10^{-19} \times 3 \times 10^8$
 $= 9.9 \times 10^{-11} \text{ J}$ ecf ✓
- $E = \frac{9.9 \times 10^{-11}}{1.6 \times 10^{-19}} \text{ eV}$ ecf ✓
 $= 6.2 \times 10^8 \text{ eV}$
- (c) $I = 10^{-8} \text{ C/s}$
- $N = 10^{-8} / 1.6 \times 10^{-19}$ ecf ✓
 $= 6.3 \times 10^{10} \text{ electrons / second}$ ✓

- (d) Volume = $9 \times 10^{-6} \times 0.1 \times 10^{-2} = 9 \times 10^{-9} \text{ m}^3$ ✓
- Number of atoms or nuclei =
- $$= 9 \times 10^{-9} \times 8900 \frac{\text{kg}}{\text{m}^3} \times 10^3 \frac{\text{g}}{\text{kg}} \times \frac{1 \text{ mol}}{63.5 \text{ g}} \times 6.0 \times 10^{23} \frac{\text{atoms}}{\text{mol}}$$
- ✓ allowed if only one mistake
- $$= 7.5 \times 10^{20} \text{ nuclei} \quad \text{ecf} \quad \checkmark$$
- (e) Area of nuclei = $7.5 \times 10^{20} \times \pi \times (10^{-15})^2$
- $$= 2.4 \times 10^{-9} \text{ m}^2 \quad \text{ecf} \quad \checkmark$$
- ratio of nuclei area/beam area = $2.4 \times 10^{-9} / 9 \times 10^6$
- $$= 2.6 \times 10^{-4} \quad \checkmark$$
- (f) No of collisions / second = $2.6 \times 10^{-4} \times 6.3 \times 10^{10}$ ecf ✓
- $$= 1.7 \times 10^7 \quad \checkmark$$

[13]

6. (a) $2\theta = 2 \times 1.2 \times 530 \times 10^{-9} / 10^{-2}$ ✓
- $$= 1.3 \times 10^{-4} \text{ radians}$$
- Diameter of circle on moon = $2\theta \times \text{distance to moon}$
- $$= 1.3 \times 10^{-4} \times 4.0 \times 10^8$$
- $$= 51 \text{ km} \quad \text{ecf} \quad \checkmark$$
- Area of circle on the moon = πr^2
- $$= 2.0 \times 10^9 \text{ m}^2 \quad \text{ecf} \quad \checkmark$$
- (b) width = $2\theta \times \text{focal length} = (2 \times 1.2 \lambda / d) \times \text{focal length}$
- $$= 2 \times 1.2 \times 530 \times 10^{-9} \times 0.15 / 10^{-2}$$
- $$= 1.9 \times 10^{-5} \text{ m} \quad \checkmark$$
- Radius of spot = $0.85 \times 10^{-5} \text{ m}$ ecf ✓
- Intensity = power/area of spot
- $$= 10 / \pi \times (0.85 \times 10^{-5})^2$$
- $$= 3.5 \times 10^{10} \text{ Wm}^{-2} \quad \text{ecf} \quad \checkmark$$
- (c) $\lambda = 3 \times 10^9 / 1.5 \times 10^9 = 0.2 \text{ m}$ ✓
- $$2\theta = 2 \times 1.2 \times 0.2 / 10$$
- $$= 0.048 \text{ radians} \quad \text{ecf} \quad \checkmark$$
- Radius of circle on earth = $0.5 \times 0.048 \times 44 \times 10^6$
- $$= 1.06 \times 10^5 \text{ m} \quad \text{ecf} \quad \checkmark$$
- Area = $\pi r^2 = 3.5 \times 10^{12} \text{ m}^2$ ecf ✓

[10]