Answers to exam-style questions

Topic 2

Where appropriate, 1 ✓ = 1 mark

1 D

2 C

3 C

4 D

5 A

6 D

7 D

8 A

9 C

10 A

11 a i The equation applies to straight line motion with acceleration g. Neither condition is satisfied here. ✓

ii This equation is the result of energy conservation so it does apply since there are no frictional forces present. ✓

b From $v=\sqrt{2gh}$ we find $h=\frac{v^2}{2g}=\frac{4.8^2}{2\times 9.81}=1.174\approx 1.2$ m. ✓

c i The kinetic energy at B is $E=\frac{1}{2}mv^2=\frac{1}{2}\times 25\times 4.8^2=28.8$ J. ✓

The frictional force is $f=\mu_K N=\mu_K mg=0.45\times 25\times 9.81=110.36$ N and so the work done by this force is the change in the kinetic energy of the block, and so $110.36\times d=28.8\Rightarrow d=0.261\approx 0.26$ m. ✓

ii The deceleration is $\frac{f}{\mu}=\frac{110.36}{25}=4.41\ \mathrm{m\,s^{-2}}$, ✓

and so $0=4.8-4.41\times t$ giving 1.1 s for the time. ✓

d The speed at B is independent of the mass. ✓

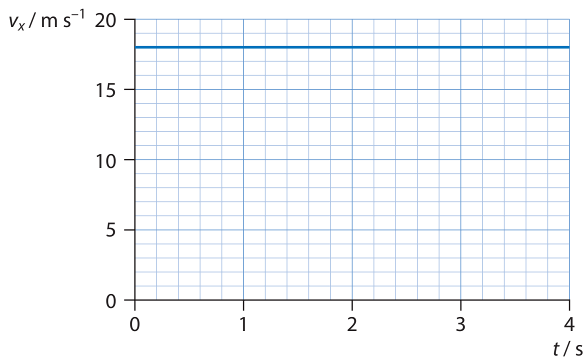
$fd=\frac{1}{2}mv^2\Rightarrow \mu_K mgd=\frac{1}{2}mv^2\Rightarrow d=\frac{v^2}{2\mu_K}$, ✓

and so the distance is also independent of the mass. ✓

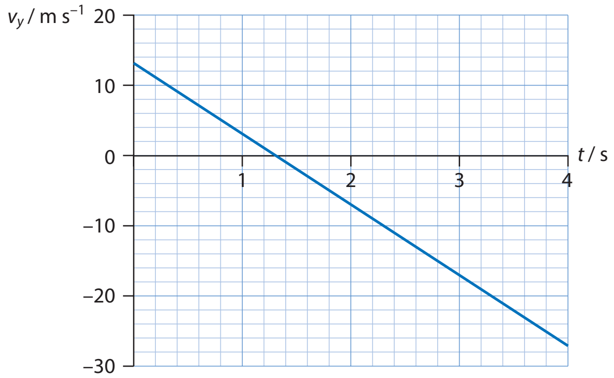
12 a i $v_x=v\cos\theta=22\times\cos 35°=18.0\approx 18\ \mathrm{m\,s^{-1}}$ ✓

$v_y=v\sin\theta=22\times\sin 35°=12.6\approx 13\ \mathrm{m\,s^{-1}}$ ✓

ii Graph as shown. ✓



Graph as shown. ✓



b **i** At maximum height: $v_y^2 = 0 = u_y^2 - 2gy$. ✓

$y = \frac{u_y^2}{2g}$ ✓

and so $y = \frac{12.6^2}{2 \times 9.8} = 8.1$ m ✓

OR

$v_y = 0 = v\sin\theta - gt$ $12.6 - 9.8t = 0$ ✓

so $t = 1.29$ s ✓

Hence $y = 12.6 \times 1.29 - \frac{1}{2} \times 9.8 \times 1.29^2 = 8.1$ m ✓

ii The force is the weight, i.e. $F = 0.20 \times 9.8 = 1.96 \approx 2.0$ N. ✓

c **i** $\frac{1}{2}mu^2 + mgh = \frac{1}{2}mv^2$ hence $v = \sqrt{u^2 + 2gh}$ ✓

$v = \sqrt{u^2 + 2gh} = \sqrt{22^2 + 2 \times 9.8 \times 32} = 33.3 \approx 32$ m s^{-1} ✓

ii $v^2 = v_x^2 + v_y^2 \Rightarrow v_y = -\sqrt{v_x^2 - v_x^2} = -\sqrt{33.3^2 - 18.0^2} = -28.0$ m s^{-1} ✓

Now $v_y = u_y \sin\theta - gt$ so $-28.0 = 12.6 - 9.8 \times t$ hence $t = 4.1$ s ✓

d **i** Smaller height. ✓
Smaller range. ✓
Steeper impact angle. ✓

ii The angle is steeper because the horizontal velocity component tends to become zero. ✓
Whereas the vertical tends to attain terminal speed and so a constant value. ✓

13 **a** **i** In 1 second the mass of air that will move down is $\rho(\pi R^2 v)$. ✓

The change of its momentum in this second is $\rho(\pi R^2 v)v = \rho\pi R^2 v^2$. ✓

And from $F = \frac{\Delta p}{\Delta t}$ this is the force. ✓

ii $\rho\pi R^2 v^2 = mg$ ✓

And so $v = \sqrt{\frac{mg}{\rho\pi R^2}} = \sqrt{\frac{0.30 \times 9.8}{1.2 \times \pi \times 0.25^2}} = 3.53 \approx 3.5\ \text{m s}^{-1}$. ✓

b The power is $P = Fv$ where $F = \rho\pi R^2 v^2$ is the force pushing down on the air and so $P = \rho\pi R^2 v^2$. ✓
So $P = 1.2 \times \pi \times 0.25^2 \times 3.53^2 = 2.936 \approx 3.0$ W ✓

c i From $F = \rho\pi R^2 v^2$ the force is now 4 times as large, i.e. $4mg$ and so the **net** force on the helicopter is $3mg$. ✓

And so the acceleration is constant at $3g$. Hence $s = \frac{1}{2} \times 3g \times t^2 \Rightarrow t = \sqrt{\frac{2s}{3g}} \approx 0.90$ s. ✓

ii $v = 3gt = \sqrt{\frac{2s}{3g}}$ ✓

$v \approx 26\ \text{m s}^{-1}$ ✓

iii The work done by the rotor is $W = Fd = 4mgd = 4 \times 0.30 \times 9.8 \times 12 = 141$ J. ✓

14 a i The area is the impulse i.e. 2.0×10^3 N s. ✓

ii The average force is found from $\bar{F}\Delta t = 2.0 \times 10^3$ N s. ✓

And so $\bar{F} = \frac{2.0 \times 10^3}{0.20} = 1.0 \times 10^4$ N. ✓

Hence the average acceleration is $\bar{a} = \frac{1.0 \times 10^4}{8.0} = 1.25 \times 10^3\ \text{m s}^{-2}$. ✓

iii The final speed is $\bar{v} = \bar{a}t = 1.25 \times 10^3 \times 0.20 = 250\ \text{m s}^{-1}$. ✓
And so the average speed is 125 m s^{-1}. ✓

iv $s = \frac{1}{2}\bar{a}t^2 = \frac{1}{2} \times 1.25 \times 10^3 \times 0.20^2$ ✓

$s = 25$ m ✓

b i The final speed is $\bar{v} = \bar{a}t = 1.25 \times 10^3 \times 0.20$, ✓
$\bar{v} = 250\ \text{m s}^{-1}$. ✓

ii The kinetic energy is $E_K = \frac{1}{2}mv^2 = \frac{1}{2} \times 8.0 \times 250^2$ ✓

$E_K = 2.5 \times 10^5$ J ✓

iii $P = \frac{E_K}{t} = \frac{2.5 \times 10^5}{0.20}$ ✓

$P = 1.25 \times 10^6$ W ✓

15 a i It is zero (because the velocity is constant). ✓

ii $F - mg\sin\theta - f = 0$ ✓

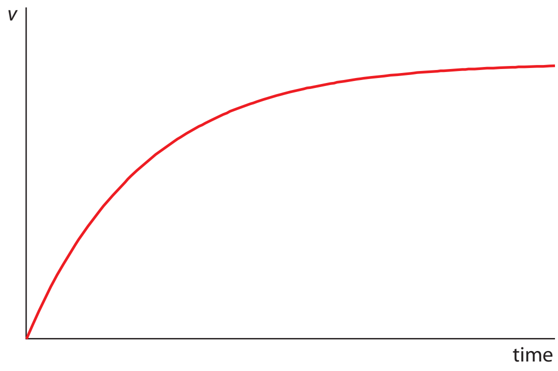
$F = mg\sin\theta + f = 1.4 \times 10^4 \times \sin 5.0° + 600$ ✓

$F = 1820$ N ✓

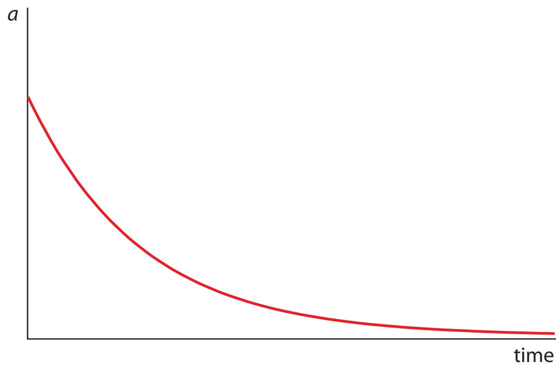
b The power used by the engine in pushing the car is $P = Fv = 1820 \times 6.2 = 1.13 \times 10^4$ W, ✓
$P = 11.3$ kW. ✓

The efficiency is then $e = \frac{11.3}{15} = 0.75$ ✓

c i Initial speed zero. ✓
Terminal speed. ✓



ii Initial acceleration not zero. ✓
And approaching zero. ✓



16 a i The change in momentum is $\Delta p = 0.090 \times (90 - 130)$, ✓
$\Delta p = -3.6\ \text{N s}$. ✓

ii This is also the negative change in the momentum of the block and so $1.20v = 3.6\ \text{N s}$ giving $v = 3.0\ \text{m s}^{-1}$. ✓

iii The initial kinetic energy is $E = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.090 \times 130^2 = 422.5\ \text{J}$. ✓

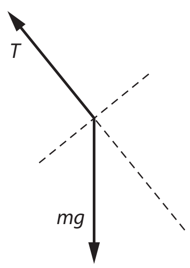
The final kinetic energy is $E = \frac{1}{2} \times 0.090 \times 90^2 + \frac{1}{2} \times 1.20 \times 3.0^2 = 369.9\ \text{J}$. The change is then $\Delta E = 369.9 - 422.5 = -52.6 \approx -53\ \text{J}$. ✓

b We have conservation of energy and so $\frac{1}{2} \times m \times 3.0^2 = m \times 9.8 \times h$ and so $h = 0.459\ \text{m}$. ✓

But $h = L - L\cos\theta$ and so $0.459 = 0.80 \times (1 - \cos\theta)$ ✓

giving $\cos\theta = 0.426$ and so $\theta = 64.77° \approx 65°$ ✓

c i It is not because there is a net force on it. ✓



ii From the diagram, $T - mg\cos\theta = m\frac{v^2}{L}$. ✓

But $v = 0$ and so $T = mg\cos\theta = 1.20 \times 9.8 \times \cos 64.77° = 5.0\ \text{N}$. ✓

$T = 5.0\ \text{N}$. ✓