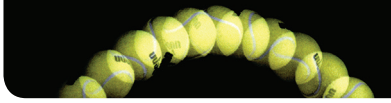


Solutions for Topic 2 – Mechanics

1. a)

b) horizontal speed $= 15 \times \cos 45 = 10.6$ m s^{-1}

vertical speed $= 15 \times \sin 45 = 10.6$ m s^{-1} upwards

$v^2 = u^2 + 2as$; $v^2 = 10.6^2 + 2 \times 9.8 \times 25 = 112 + 490 = 602$

$v = \pm 24.5$ m s^{-1} (positive value is correct one to use)

so speed is $\sqrt{10.6^2 + 24.5^2}$

$= 27$ m s^{-1}

2. a) (i) $h = \frac{v^2}{2g} = 3.2$ m

(ii) $t = \frac{u}{g} = 0.80$ s

b) time to go from top of cliff to the sea $= 3.0 - 1.6 = 1.4$ s

$s = 8.0 \times 1.4 + 5.0 \times (1.4)^2 = 21$ m;

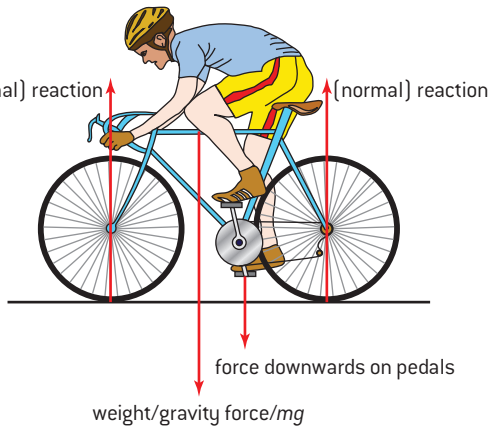
3. travels vertically 1.25 m in 0.5 s;

$g = \frac{2s}{t^2}$

to give $g = 10\ (\pm 1)$ m s^{-2}

4. a) (i) Zero

(ii)



(iii) The drag force is equal to the forward force; the net force is zero and therefore the acceleration is zero.

b) (i) acceleration $= \frac{\text{resistive force}}{\text{mass}} = \frac{40}{70} = 0.57$ m s^{-2}

(ii) $v^2 = u^2 + 2as$; $0 = 64 - (2 \times 0.57 \times s)$; $s = 56$ m

(iii) air resistance ***or*** bearing friction ***or*** effectiveness of brakes depends on speed; air resistance reduced as speed drops, estimate will be too low, stopping distance will be further

5. The net force on the car is $0.3 \times 1000 = 300$ N. There is an additional drag force of 500 N.
$T = 300 + 500 = 800$ N.

6. $T_1 \sin 60 = T_2 \sin 30$

$T_1 \cos 60 + T_2 \cos 30 = 3800$

$T_1 = 1900$ N; $T_2 = 3300$ N

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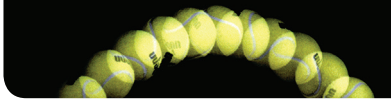


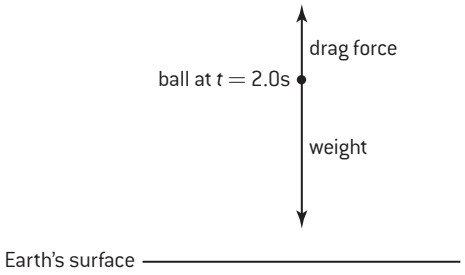
7. a) power is 0.66 kW (read off from graph)

b) power = frictional force × speed

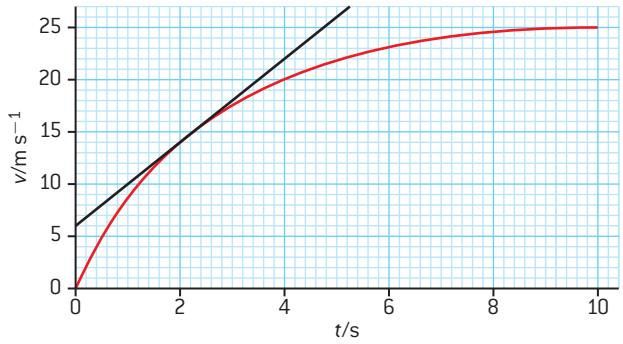
force $= \frac{660}{2} = 330$ N

8. a) use the area under the graph as this is $v \times t$

b) (i)



(ii)



the acceleration of the ball is equal to the gradient of the graph gradient $= \frac{25 - 6}{4.8 - 0}$

$= 4.0$ m s^{-2}

(iii) The net force on the ball is 2 N, the weight is 4.9 N, so the difference between these is the magnitude of the drag force = 2.9 N.

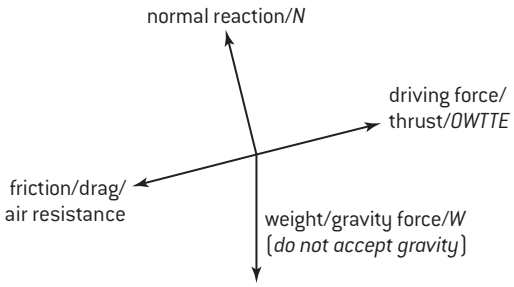
(iv) At 5.0 s the gradient is smaller and therefore the acceleration is less than at 2.0 s. The weight is constant and therefore the drag force is greater.

c) gain in kinetic energy $= \frac{1}{2} \times 0.5 \times 25^2 = 156$ J

loss in gravitational potential energy $= 0.5 \times 9.8 \times 190 = 931$ J

change (loss) in energy $= 931 - 156 = 775$ J

9. a) (i)



(ii) zero

b) input power $= \frac{\text{output power}}{\text{efficiency}} = \frac{70}{0.35}$

$= 200$ kW

c) height gained in 1 s $= 6.2 \sin(6) = 0.648$ (m)

rate of change of PE $= 8.5 \times 10^3 \times 9.81 \times 0.648$

$= 5.4 \times 10^4$ W

d) $F = \left(\frac{p}{v}\right) = \frac{1.6 \times 10^4}{6.2}$

$= 2.6$ kN

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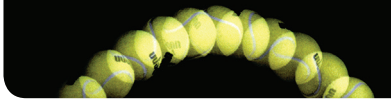

10. a) **(i)** momentum before $= 800 \times 5 = 4\,000$ N s

momentum after $= 2\,000v$

conservation of momentum gives $v = 2.0$ m s^{-1}

(ii) KE before $= 400 \times 25 = 10\,000$ J KE after $= 1\,000 \times 4 = 4\,000$ J
loss in KE $= 6\,000$ J;

b) transformed / changed into heat (internal energy) and sound

11. a) momentum of object $= 2 \times 10^3 \times 6.0$

momentum after collision $= 2.4 \times 10^3 \times v$

use conservation of momentum, $2 \times 10^3 \times 6.0 = 2.4 \times 10^3 \times v$

$v = 5.0$ m s^{-1}

b) KE of object and bar + change in PE $= 0.5 \times 2.4 \times 10^3 \times 25 + 2.4 \times 10^3 \times 10 \times 0.75$
use $\Delta E = Fd$, $4.8 \times 10^4 = F \times 0.75$
$F = 64$ kN

12. a) time $= \dfrac{81}{2.2 \times 10^{-25} \times 77 \times 10^{18}} = 4.8 \times 10^7$ s

b) rate of change of momentum of the xenon atoms

$= 77 \times 10^{18} \times 2.2 \times 10^{-25} \times 3.0 \times 10^4$

$= 0.51$ N

= mass × acceleration

where mass $= (540 + 81)$ kg

acceleration of spaceship $= \dfrac{0.51}{621}$

$= 8.2 \times 10^{-4}$ m s^{-2}

c) $a = \dfrac{F}{m}$

since m is decreasing with time, then a will be increasing with time

d) change in speed = area under graph

$= (8.0 \times 4.8) \times 10^2 + \dfrac{1}{2}(4.8 \times 1.4) \times 10^2$

final speed $= (8.0 \times 4.8) \times 10^2 + \dfrac{1}{2}(4.8 \times 1.4) \times 10^2 + 1.2 \times 10^3\ 5.4 \times 10^3$ m s^{-1}

13. a) centripetal force $= \dfrac{(350 \times 2.6^2)}{5.8} = 410$ N

tension $= 410 + (350 \times 9.8) = 3800$ N

b) idea of use of area under graph

distance $= \dfrac{1}{2} \times 0.15 \times 2.6$

$= 0.195$ m

c) idea of momentum as mv

total change $(= 2.6 \times 350) = 910$ N s

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