5.1 Forces

5.6 Newton's laws

1. (a) Force is a vector because it has direction. The arrows are pointing up and down

   (b) The forces are the same size because the arrows have the same length

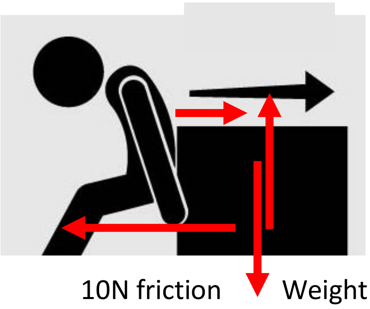
   (c) Weight (down) Normal Contact Force (up)

   (d) Normal Contact Force is obviously a contact force, Gravity is a non-contact force

   (e) Weight = mg = 0.2kg x 10N/kg = 2N. Normal Contact force is also 2N

   (f) Newton's 2nd law. Object is standing still, constant velocity = 0. Must be no resultant force

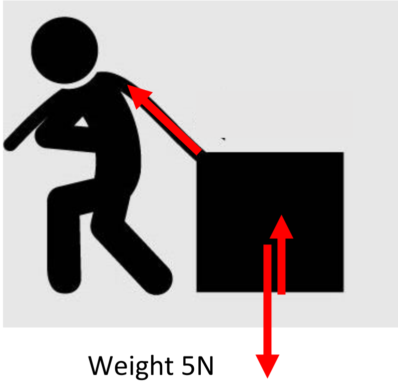
2.

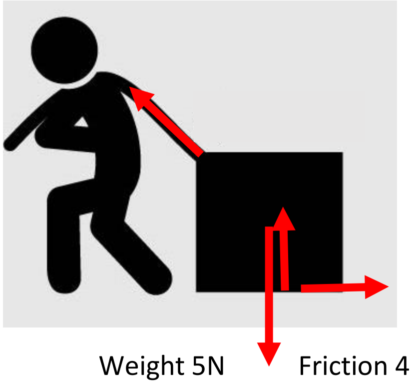


Resultant force vertical = 0	Resultant force vertical = 0
Resultant force horizontal = 5N left	Resultant force horizontal = 3N right
<u>If initially stationary</u>	
Box stays where it is	Box accelerates to the right
<u>If initially moving right</u>	
Box decelerates	Box accelerates to the right

HIGHER

Box is initially staionary





Vertical component of pull = 5sin30 N	
+ Normal Contact force = 5N up	
So no resultant force vertical	No resultant force vertical
Horizontal component of pull = 5cos30 N	= 4.33N
is only horizontal force	No resultant force horizontal
so box accelerates to the left	so object stays still

If box was initially moving to the right

Box decelerates	Box continues to move to the right with a constant velocity

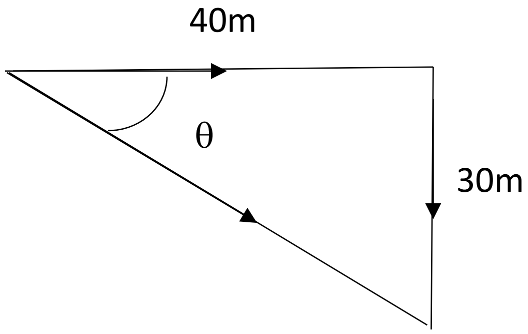
5.6 Forces and Motion

1. Total distance travelled = 60m + 20m = 80m

   The final displacement = 60m – 20m = 40m east

   The average speed = $\frac{80\text{m}}{40\text{s}}$ = 2m/s

   The average velocity = $\frac{40\text{m}}{40\text{s}}$ = 1m/s east

2. 

   Total distance travelled = 40m + 30m = 70m

   Angle θ = $\tan^{-1}\frac{30}{40}$ = 37°

   The final displacement = $\sqrt{(40^2 + 30^2)}$ = 50m on a bearing 127°

   The average speed = $\frac{70\text{m}}{30\text{s}}$ = 2.3 m/s

   The average velocity = $\frac{50\text{m}}{30\text{s}}$ = 1.7 m/s on a bearing of 127°

3. $a = \frac{v - u}{t} = \frac{60 - 0 \text{ mph}}{2\text{s}}$ = 30mph/s

   60mph = 60 x $\frac{1600\text{m}}{3600\text{s}}$ = 26.7 m/s

   The acceleration of the Ferrari = $\frac{26.7 \text{ m/s}}{2\text{s}}$ = 13.35 m/s^2

4. $a = \frac{v^2 - u^2}{2s} = \frac{30^2 - 20^2}{50}$ = 10 m/s^2

6.1.4 Distance time graphs

6.1.5 Velocity time graphs

1. Average speed, 1st section = $\frac{4 \text{ miles}}{1\text{h}}$ = 4mph

2nd section = 0

3rd section = $\frac{(\ 8 - 4\ ) \text{ miles}}{(\ 2.5 - 1.5\ ) \text{ h}}$ = 4mph

4th section = 0

5th section = ($\frac{8 - 0\ ) \text{ miles}}{(\ 5.5 - 3.5\ 0 \text{ h}}$ = 4mph (backwards)

2. Acceleration, 1st section = 0

2nd section = $\frac{(\ 8 - 0\ ) \text{ m/s}}{(\ 5 - 3\ ) \text{ s}}$ = 4 m/s^2

3rd section = 0

4th section = $\frac{(\ 0 - 8\ ) \text{ m/s}}{(\ 10 - 8\ ) \text{ s}}$ = - 4 m/s^2 (deceleration)

Distance travelled, 1st section = 0

2nd section = ½ x 2s x 8m/s = 8m

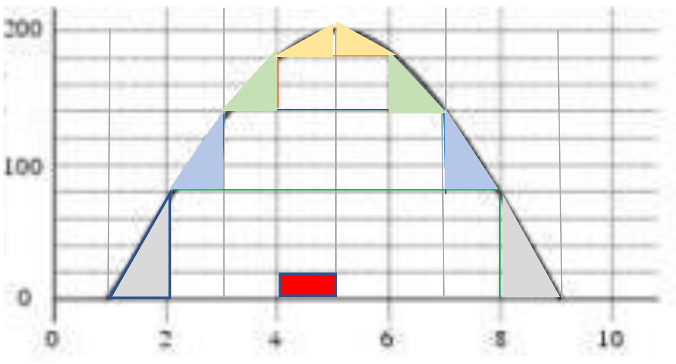
3rd section = 3s x 8m/s = 24m

4th section = ½ x 2s x 8m/s = 8m

HIGHER

3. a = $\frac{(\ 1500 - 2500\ ) \text{ m/s}}{(\ 10.4 - 6.4\ ) \text{ s}}$ = - 250 m/s^2

4. v / m/s

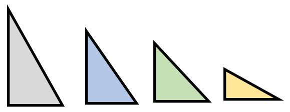


t / s

Area of 1 rectangle 🟥

1s x 20m/s = 40m

Number of rectangles under graph = 24 + 12 + 4 + 4 + 3 + 2 + 2



Distance = 51 x 40m = 2040m

5.2 Work

5.6.3 Forces and braking

1. (a) 2N x 3m = 6 J

   (b) 6N x 3m = 18 J

2. (a) d = v x t = 13.3m/s x 0.6s = 7.98 m = 8.0m (2 sig figs)

   (b) (i) doubling the speed doubles the thinking distance so 16m

   (ii) doubling the speed quadruples the braking distance so 64m

5.7 Momentum

1. (a) 600 x 20 + 800 x 10 = 1400 v

   20000 = 1400 v

   14.3 m/s = v

   (b) before $\frac{1}{2} \times 600 \times 20^2 + \frac{1}{2} \times 800 \times 10^2 = 160\,000$ J

   after $\frac{1}{2} \times 1400 \times 14.3^2 = 143\,000$ J

   (c) Collison is inelastic because there is a decrease in kinetic energy

2. (a) Let m = mass of electron

   $0.1\cancel{m}c = 0.1\cancel{m}\cancel{c} + \cancel{m}v$

   $v = 0$

   The incoming electron stops

   (b) before $\frac{1}{2} \times m \times 0.01c^2 = 0.005mc^2$

   after $\frac{1}{2} \times m \times 0.01c^2 = 0.005mc^2$

   (c) Interaction is elastic because there is no loss of kinetic energy

3. $F = \frac{mv - mu}{t} = \frac{(0 - 0.05kg \times 10m/s)}{0.1s} = -5N$ (negative because up)

4. Carton squashes on impact, increasing impact time, decreasing impact force

5.3 Forces and Elasticity

1. (a) $k = \frac{F}{x} = \frac{1.6N}{0.08m} = 20\ N/m$

   (b) $x = \frac{F}{k} = \frac{0.6N}{20N/m} = 0.03\ m$

   (c) $F = kx = 20N/m \times 0.062m = 1.24\ N$

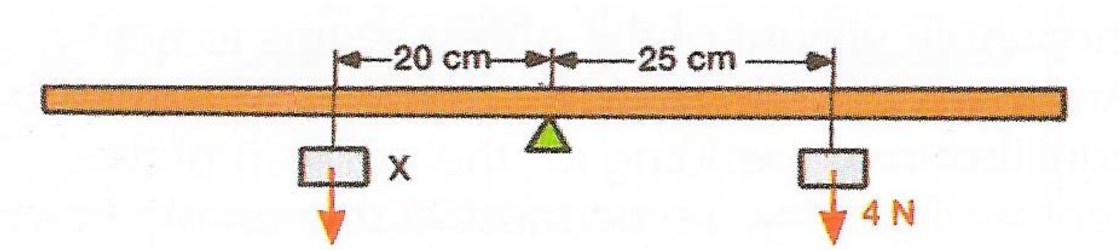
   (d) $W = ½Fx = ½ \times 1.6N \times 0.08m = 0.064\ J$

2. (a) $k = \frac{2W}{x^2} = \frac{2 \times 20\ J}{(0.5m)^2} = 160\ N/m$

   (b) $F = kx = 160N/m \times 0.5m = 80\ N$

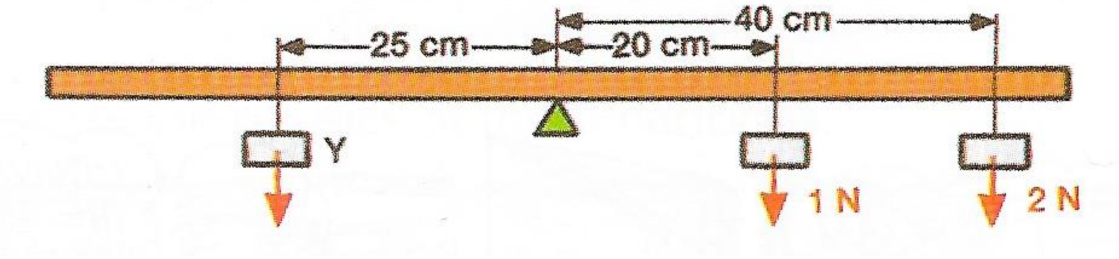
5.4 Turning forces

1.



$20X = 4 \times 25$

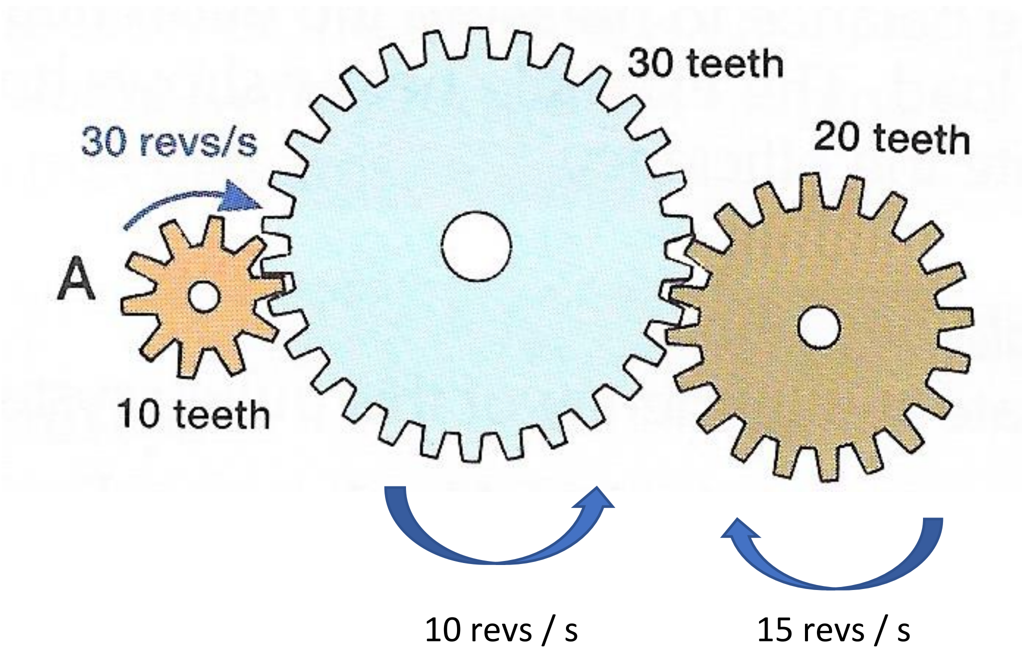
$X = 5\ N$



$25Y = 1 \times 20 + 2 \times 40$

$Y = 4\ N$

2.



5.5 Pressure

1. $P = \frac{F}{A} = \frac{0.02\text{kg} \times 10\text{N/kg}}{0.04\text{m} \times 0.04\text{m}} = 125 \text{ Pa}$

2. (a) $P = \rho gh = 1000\text{kg/m}^3 \times 10\text{N/kg} \times 2\text{m} = 20\,000 \text{ Pa}$

   (b) Upthrust = PA = 20 000Pa x 0.04m x 0.04m = 32 N