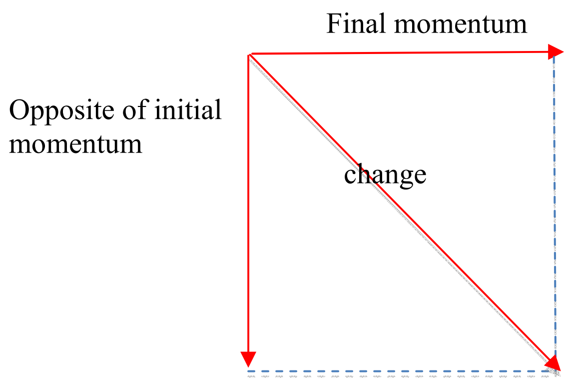
Mark scheme for Extension Worksheet – Topic 2, Worksheet 2

1 The initial momentum is 0.25 × 4.0 = 1.0 N s directed north and the final momentum has the same magnitude directed east. The change in momentum is given by the following vector diagram:



We used $\Delta\vec{p} = \vec{p}_f - \vec{p}_i = \vec{p}_f + (-\vec{p}_i)$; Then the magnitude of $\Delta\vec{p}$ is $\sqrt{1.0^2 + 1.0^2}$ = 1.41 N s; directed south-east. [3]

2 **a** The force is the rate of change of the gases' momentum; and this is 200 × 1800 = 36 000 N; [2]

b the initial net force on the rocket is therefore 36 000 – 4000 ×8.0 = 4000 N; [1]

c initially the mass is still 4000 kg and so $a = \dfrac{4000}{4000}$ = 1.0 m s^{-1}. [1]

3 **a** The speed is $v = \sqrt{2gh}$; $v = \sqrt{2 \times 9.8 \times 2.0} = 6.26 \approx 6.3$ m s^{-1} [2]

b Conservation of momentum to get 54 × 6.26 = (54 + 18)u; i.e. u = 4.695 ≈ 4.7 m s^{-1} [2]

c The work done by the net force on the pile is

$\Delta E_K = 0 - \dfrac{1}{2}(54+18) \times 4.695 = -793.5$ J; this work is $F \times 0.50 \times (-1)$ where F is the net force and so $-F \times 0.50 = -793.5 \Rightarrow F = \dfrac{793.5}{0.50} = 1587$ N; let R be the upward force the ground exerts on the pile, then the net force is

$F = R - W \Rightarrow R = F + W = 1587 + (54+18) \times 9.8 = 2293 \approx 2300$ N [3]

4 The gravitational potential energy decreased by ΔE_P and in the absence of resistance forces this would have gone into kinetic energy. But an amount of energy Q has gone into thermal energy and so only what is left, i.e. $\Delta E_P - Q$ has now gone into kinetic energy, **C**. [1]

5 **a** The maximum acceleration occurs for the maximum force which is 4.0 N and so $a_{\max} = \frac{4.0}{6.0} = 0.667 \approx 0.67 \text{ m s}^{-2}$; [1]

b The work done is the area under the curve; i.e. $\frac{1}{2} \times 2 \times 4 + 2 \times 2 = 8.0 \text{ J}$; [2]

c The change in kinetic energy is the work done by the net force; and so $\frac{1}{2} \times 6.0 \times v^2 = 8.0 \Rightarrow v = 1.63 \text{ m s}^{-1}$ [2]

6 **a** The acceleration is maximum when the force is maximum i.e. $a_{\max} = \frac{2.0}{0.5} = 4.0 \text{ m s}^{-2}$ [1]

b The area under the curve is the impulse, i.e. the change in momentum and this is $\frac{10+4}{2} \times 2 = 14 \text{ N s}$; hence $0.50v - 0 = 14$ N s and so $v = 28 \text{ m s}^{-1}$ [3]

c The change in kinetic energy is $\frac{1}{2} \times 0.50 \times 28^2 = 196 \text{ J}$; this takes place in 10 s so the average power is 19.6 W [2]

d The average force is $F_{\text{ave}} = \frac{14}{10} = 1.4 \text{ N}$; [1]

e The average acceleration is $a_{\text{ave}} = \frac{1.4}{0.5} = 2.8 \text{ m s}^{-2}$ and so the distance travelled is $s = \frac{1}{2}at^2 = \frac{1}{2} \times 2.8 \times 10^2 = 140 \text{ m}$ [2]