1) i) $K.E. = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 50 \times 10^2$

$= 2500\ J$

ii) $K.E. = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 5000 \times 4^2$

$= 40000\ J$

iii) $K.E. = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 7000 \times 10^3 \times 40^2$

$= 5.6 \times 10^9\ J$

iv) $K.E = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 7.4 \times 10^{22} \times 1000^2$

$= 3.7 \times 10^{28}\ J$

v) $K.E. = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 2 \times 10^{-19} \times (10^{-3})^2$

$= 10^{-25}\ J$

2) i) Man provides force of 200N

Work done = force x distance moved

$= 200 \times 5$

$= 1000\ J$

ii) Work done by man + work done by resistance = change in kinetic energy

Work done by man $- 5 \times 200 = \frac{1}{2} \times 35 \times 2^2$

Work done by man $= 70 + 1000$

$= 1070\ J$

iii) Man work done $- 5 \times 200 = -\frac{1}{2} \times 35 \times 2^2$

Man work done $= -70 + 1000$

$= 930\ J$

iv) Man does no work

3) i) $K.E. = \frac{1}{2}mv^2 = \frac{1}{2} \times 60 \times 12^2$

$= 4320\ J$

ii) Work done = change in K.E

$= 4320\ J$

iii) Work = Force x distance

$4320 = 30F$

$F = \frac{4320}{30} = 144\ N$

iv) Force = mass x acceleration

$144 = 60 \times a$

$\Rightarrow a = 2.4\ ms^{-2}$

3 iv) (cont) Using $v^2 = u^2 + 2as$

$v^2 = 0 + 2 \times 2.4 \times 30$

$v^2 = 144$

$v = 12\ ms^{-1}$

Consistent with work energy approach

---

4) i) Work done = change in K.E

$= \frac{1}{2}mv^2 - 0$

$= \frac{1}{2} \times 1200 \times 30^2$

$= 540{,}000\ J$

Answer does not depend on assumption that driving force is constant

---

4 ii) Work done = Force × distance

$540{,}000 = 150F$

$F = \frac{540{,}000}{150}$

$F = 3600\ N$

---

5) i) Work done by brakes = change in K.E.

$= 0 - \frac{1}{2}mu^2$

$= 0 - \frac{1}{2} \times 1600 \times 25^2$

$= -500{,}000\ J$

---

5 ii) Work done = Force × distance

$-500{,}000 = F \times 75$

$F = \frac{-500{,}000}{75}$

$F = -6667\ N$

Retarding force of 6667 N

---

6) i) a) Total work done = change in K.E.

$= \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$= \frac{1}{2}m(v^2 - u^2)$

$= \frac{1}{2} \times 500(5^2 - 2^2)$

$= 5250\ J$

---

b) $= \frac{1}{2}m(v^2 - u^2)$

$= \frac{1}{2} \times 500(3^2 - 8^2)$

$= -13{,}750\ J$

---

6 ii) Work done by uplift force

a) $= mgh + 5250$

$= 500 \times 9.8 \times 100 + 5250$

$= 495{,}250\ J$

---

b) $= mgh + -13{,}750$

$= 500 \times 9.8 \times 100 - 13{,}750 = 476{,}250\ J$

7) i)

$K.E = \frac{1}{2} m v^2$

$= \frac{1}{2} \times 0.02 \times 80^2$

$= 64$ J

7 ii)

Dissipated as heat and sound

7 iii)

Work done stopping bullet

$= -64$ J

7 iv)

Work done = Force × distance

$-64 = 0.16F$

$F = \frac{-64}{0.16} = -400$ N

Resistive force = 400 N

7 v)

Assuming resistive force of post = 400 N

Work done stopping bullet

= Force × distance

$= -400 \times 0.20$

$= -80$ J

K.E. of bullet on entry

$= 80$ J

$\frac{1}{2} m v^2 = 80$

$\frac{1}{2} \times 0.02 v^2 = 80$

$\Rightarrow v^2 = 8000$

$\Rightarrow v = 89.4 \text{ ms}^{-1}$

8) i)

Work done = change in KE

$= 0 - \frac{1}{2} m u^2$

$= 0 - \frac{1}{2} \times 1300 \times 22^2$

$= -314,600$ J

8 ii)

Work done = Force × distance

$-314,600 = 38F$

$F = \frac{-314,600}{38}$

$F = -8279$ N

Average force exerted by brakes

$= 8279$ N

8 iii)

Dissipated as heat and sound

8 iv)

Some of work done is dissipated

9) i)

Increase in K.E = Force × distance

$= (2800 - 600) \times 20$
$+ (2100 - 600) \times 40$
$+ (1400 - 600) \times 80$
$+ (1000 - 600) \times 100$

$= 208,000$ J

9 cont) Increase in KE $= \frac{1}{2}mv^2$

$\Rightarrow \frac{1}{2} \times 1200v^2 = 208{,}000$

$v^2 = \frac{208{,}000}{600} = 346.67$

$v = 18.6 \text{ ms}^{-1}$

10)

i) $F = -\mu R = -0.4 \times 60g$

$F = -240 \text{ N}$

ii) Distance = area under graph

= area of trapezium

$= \frac{1}{2}(7+4) \times 1$

$= 5.5 \text{ m}$

iii) No overall change in K.E so work done by woman = − work done by friction

Work done by woman = F × d

$= 240 \times 5.5 = 1320 \text{ J}$

iv) From graph acceleration in first 2 s

$= \frac{1}{2} = 0.5 \text{ ms}^{-2}$

Net Force = ma

$= 60 \times 0.5$

$= 30 \text{ N}$

Force exerted by woman

$= 30 + 240 = 270 \text{ N}$

Distance in first 2s

$s = ut + \frac{1}{2}at^2$

$s = 0 + \frac{1}{2} \times 0.5 \times 2^2 = 1 \text{ m}$

∴ Woman does work of $270 \times 1 = 270 \text{ J}$

v) Between 2s and 6s

Woman exerts force of 240 N
Speed is 1 ms^{-1} so distance = 4 m

Work done by woman $= 240 \times 4 = 960 \text{ J}$

Between 6s and 7s

Acceleration $= -1 \text{ ms}^{-2}$
Net force $= 60 \times -1 = -60 \text{ N}$
∴ Woman exerts force $= 240 - 60 = 180 \text{ N}$
Distance travelled = 0.5 m (from graph)

Work done by woman $= 180 \times 0.5 = 90 \text{ J}$

vi) $270 + 960 + 90 = 1320 \text{ J}$

∴ parts (iv) and (v) are consistent with part (iii)

//

MEI MECHANICS 2 WORK AND ENERGY EXERCISE 5B

1 i) P.E. = mgh

= 2.5 × 9.8 × 0.4

= 9.8 J

ii)

P.E. = mgh

= 3 × 9.8 × 5 sin 40°

= 94.5 J

iii)

P.E. = mgh

= 2 × 9.8 × −3

= −58.8 J

iv)

P.E. = mgh

= 1.6 × 9.8 × −4 cos 20°

= −58.9 J

2) i) Change in P.E. = $mg(h_B - h_A)$

= 2 × 9.8 (1.2 − 2.6)

= −27.44 J

ii)

Change in P.E. = $mg(h_B - h_A)$

= 4 × 9.8 (2.2 − 0.8)

= +54.88 J

iii)

Change in P.E. = $mg(h_B - h_A)$

= 0.6 × 9.8 (−3 − −1)

= −11.76 J

3)

Work done = increase in P.E.

= mgh = 1.2 × 9.8 × 1.5

= 17.64 J

4)

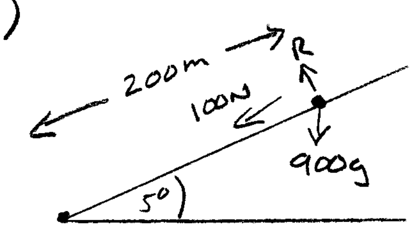
Increase in P.E.

= mgh = 60 × 9.8 × (12 × 3.3)

= 23,284.8 J

= 23,300 J to 3 s.f.

5) i)



Work against gravity = mgh

= 900 × 9.8 × 200 sin 5°

= 153,743 J

= 154,000 J to 3 sig fig

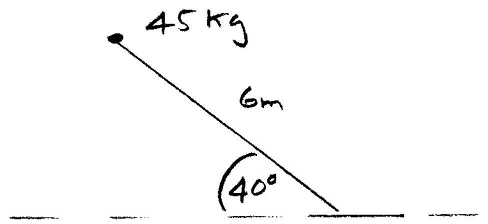
5ii)

Work against resistive force

= F × d = 100 × 200

= 20,000 J

7ii) Increase is the same as in part (i). This is regardless of the route between the same start and end points.

8) 

i)

a) Decrease in gpe $= mgh$

$= 45 \times 9.8 \times 6 \sin 40°$

$= 1701 \text{ J}$

b) Work done = change in k.e.

$1701 = \frac{1}{2}mv^2$

$1701 = \frac{1}{2} \times 45 v^2$

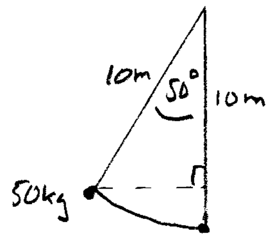
$\Rightarrow v = \sqrt{\frac{1701}{22.5}}$

$\Rightarrow v = 8.69 \text{ ms}^{-1}$

ii) Still same loss of 1701 J in gpe

However, friction would do work against movement so less energy available to increase k.e.

Therefore final speed would be lower.

9) 

i) Loss in height $= 10 - 10\cos 50°$

Loss in gpe $= mgh$

$= 50 \times 9.8 \times (10 - 10\cos 50°)$

$= 1750 \text{ J}$

ii) Loss in gpe = gain in K.E

$\frac{1}{2}mv^2 = 1750.34$

$\frac{1}{2} \times 50 v^2 = 1750.34$

$v = \sqrt{\frac{1750.34}{25}}$

$v = 8.37 \text{ ms}^{-1}$

iii) 50° since air resistance is being neglected

iv) Tension is always at 90° to direction of movement and so does no work.

10)

i) Relative to ground gpe $= mgh$

$= 0.2 \times 9.8 \times 78.4$

$= 153.664 \text{ N}$

$= 154 \text{ N}$ to 3 sig fig

5iii) Distance moved against gravity is $200\sin 5^\circ$ m not 200 m

5iv) Loss in K.E $= \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$= \frac{1}{2} \times 900 (12^2 - 8^2)$

$= 36000$ J

Total work done by engine

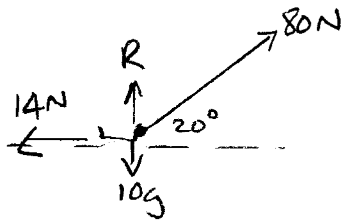
= Work against gravity
+ work against resistance
− loss in K.E.

$= 153,743 + 20,000 - 36,000$

$= 137,743$ J

$= 138,000$ J to 3 sig fig

6)



i)
a) Work done by tension in rope

$= 8\cos 20^\circ \times 20$

(= Component of force in direction of movement × distance moved)

$= 1503.5$ N

$= 1500$ N to 3 sig fig

b) Work done by resistance force
$= 14 \times (-20) = -280$ N

ii)
a) Starts at rest

Total work done = change in K.E

$1503.5 - 280 = \frac{1}{2}mv^2 - 0$

$1223.5 = \frac{1}{2} \times 10 v^2$

$\Rightarrow v^2 = 244.7$

$v = 15.6$ ms^{-1}

b) Starts at 4 ms^{-1}

$1223.5 = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$1223.5 = \frac{1}{2} \times 10 (v^2 - 4^2)$

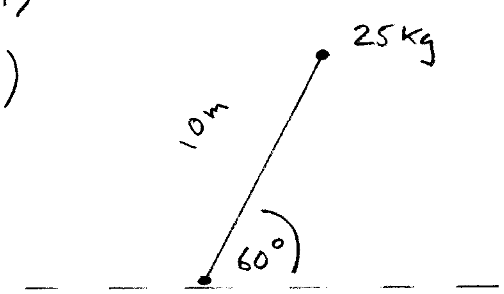
$244.7 = v^2 - 16$

$260.7 = v^2$

$\Rightarrow v = 16.1$ ms^{-1}

7)

i)



Increase in gpe

$= mgh = 25 \times 9.8 \times 10\sin 60$

$= 2122$ J

$= 2120$ J to 3 sig fig.

10ii) When stone has fallen x m t s later

$gpe = 154 - 1.96x$

10iii)

Assuming air resistance negligible

Loss in P.E = gain in K.E.

$1.96x = \frac{1}{2}mv^2$

$1.96x = 0.1v^2$

$19.6x = v^2$

Max $x = 78.4$ m

$\therefore$ max V when

$v^2 = 19.6 \times 78.4$

$v = 39.2$

But $v = u + at$

$V = 0 + 9.8t$

$\therefore$ max $t = \frac{39.2}{9.8} = 4$ s

True for $0 \leq t \leq 4$ s

iv)

When $x = \frac{78.4}{2} = 39.2$

$v^2 = 19.6 \times 39.2$

$v = 27.7 \text{ ms}^{-1}$

v) From iii) max $V = 39.2$

half final speed $v = \frac{39.2}{2} = 19.6 \text{ ms}^{-1}$

Now $19.6x = v^2$

$19.6x = 19.6^2$

$\Rightarrow x = 19.6$ m

Height $= 78.4 - x$
$= 78.4 - 19.6 = 58.8$ m