FURTHER MECHANICS 1 UNIT 2 WORK, ENERGY, POWER

1) a) $KE = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 2 \times 5^2$

$= 25\ J$

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b) Increase in GPE $= mgh$

$= 2 \times 9.8 \times 0.1$

$= 1.96\ J$

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c) $m_1 : m_2 = 2 : 3$

Say $m_1 = k$, $m_2 = 1.5k$

$\frac{1}{2}m_1v^2 = m_2 g h$

$\frac{1}{2}k(-v)^2 = 1.5kgh$

$v^2 = 3gh$

$\frac{v^2}{3g} = h$

$h = \frac{v^2}{3g}$

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2) a) Work done = Force x distance

$= 80 \times 10$

$= 800\ J$

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b) $F\cos 20° \times 10 = 800\ J$

$F = \frac{800}{10\cos 20°}$

$F = 85\ N$ to 2 s.f.

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c) Power $= \frac{\text{Work done}}{\text{Time taken}}$

$= \frac{F \times d}{t}$

But $\frac{d}{t}$ = average velocity

∴ Power = Driving Force x Avge vely

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d) i) 'a' had greater power output since same work was done in less time

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ii) No movement in vertical direction, so no work done in that direction so no power component

WORK, ENERGY, POWER

3) a) $KE = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 50 \times 25^2$

$= 15625\ J$

KE reduced to 0

Work done by drag force = 15625 J

$F \times d = 15625$

$F \times 100 = 15625$

$F = 156.25\ N$

$F = 156\ N$ to 3 s.f.

b) Initial $KE = \frac{1}{2}mv^2$

$= \frac{1}{2} m \times 25^2$

$= 312.5m\ J$

Final $KE = \frac{1}{2} m \times 4^2$

$= 8m\ J$

Loss in KE = 304.5m J

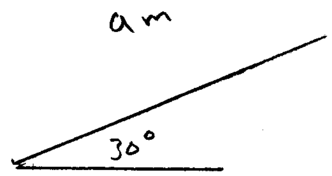
= work done by resisting force of 156.25 N

Fd = work done

$156.25 \times 100 = 304.5m$

$\frac{15625}{304.5} = m$

$m = 51.3\ kg$ to 3 s.f.

c) 

Loss in KE = Work against Friction + Work against Gravity

$\frac{1}{2}mu^2 - \frac{1}{2}mv^2 = 9\mu R + mgh$

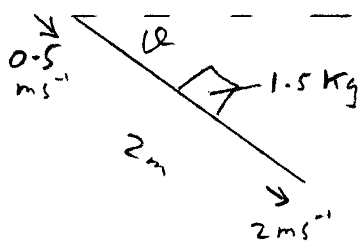
$\frac{1}{2}m(25^2 - 22^2) = 9\mu mg\cos 30 + mg\,9\sin 30$

$\frac{1}{2}(141) = 9\mu \times 9.8\cos 30 + 9 \times 9.8\sin 30$

$70.5 = 76.383\mu + 44.1$

$\frac{70.5 - 44.1}{76.383} = \mu$

$\mu = 0.346$

4) a) 

Gain in KE = Loss in GPE

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

$\frac{1}{2}m(2^2 - 0.5^2) = mg \times 2\sin\theta$

$m(3.75) = 4mg\sin\theta$

$\frac{3.75m}{4mg} = \sin\theta$

4a) cont)

$$\theta = \sin^{-1}\left(\frac{3.75}{4 \times 9.8}\right)$$

$$\theta = 5.49^\circ$$

Assumption perfectly smooth means no energy lost to friction. In practice friction would cause exit speed to be less than $2\ ms^{-1}$ at this angle.

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b) Loss in GPE = Gain in KE + Work against Friction

$$mgh = \tfrac{1}{2}mv^2 - \tfrac{1}{2}mu^2 + \mu R \times 2$$

$$mgh = \tfrac{1}{2}mv^2 - \tfrac{1}{2}mu^2 + \mu mg\cos\theta \times 2$$

$$2gh = v^2 - u^2 + 4 \times 0.05 \times 9.8\cos 7^\circ$$

$$2 \times 9.8 \times 2\sin 7^\circ + 0.5^2 - 1.96\cos 7^\circ = v^2$$

$$v^2 = 3.08189$$

$$v = 1.76\ ms^{-1} \text{ to 3 s.f.}$$

so $v < 2\ ms^{-1}$

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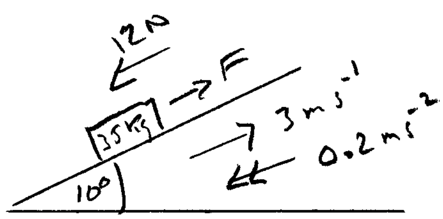
5)

a)



Let F be drive force

$$F - 12 - mg\sin\theta = ma$$

$$F = 35(-0.2) + 12 + 35 \times 9.8\sin 10$$

$$F = 64.56\text{N}$$

Power = Fv

$$= 64.56 \times 3$$

$$= 194 \text{ Watts to 3 s.f.}$$

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b) Loss in KE = Work against Friction + Gain in GPE

$$\tfrac{1}{2}mu^2 = 12d + mgh$$

where d = distance AB

$$\tfrac{1}{2} \times 35 \times 1.5^2 = 12d + 35 \times 9.8 \times d\sin 10^\circ$$

$$39.375 = d(12 + 59.561)$$

$$d = \frac{39.375}{71.561}$$

d 0.55 m to 2 s.f.

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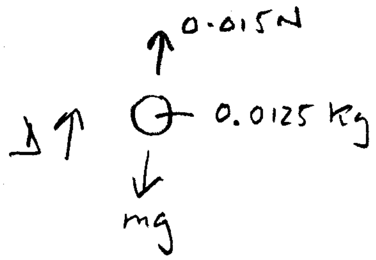
6) a)



At terminal velocity $v = 0.8$

$$D + 0.015 = mg$$

$D = kv$ say for some constant k

$$0.8k + 0.015 = 0.0125g$$

$$k = \frac{0.0125g - 0.015}{0.8}$$

$$k = \frac{g}{64} - \frac{3}{160}$$

$$k = \frac{5g - 6}{320}$$

$$\therefore\ D = kv = \frac{(5g-6)}{320} v$$

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b) After falling 1.1 m and reaching terminal velocity resistive forces are constant

$$= 0.015 + D$$

$$= 0.015 + \frac{(5g-6)}{320} \times 0.8$$

Falls another x m say

Work Done against resistance

$$= 30\text{ J} = \left(0.015 + \frac{(5g-6)}{320} \times 0.8\right) x$$

$$x = \frac{30}{\left(0.015 + \frac{(5g-6)}{320} \times 0.8\right)}$$

$$x = 244.9 \text{ m}$$

Depth of lake

$$244.9 + 1.1$$

$$= 246\text{ m} \quad \text{to 3 s.f.}$$