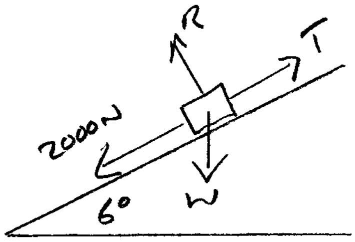
12) i)



$v = 60\text{ km h}^{-1} = \frac{60 \times 1000}{3600}\text{ m s}^{-1}$

$= 16.667\text{ m s}^{-1}$

mass = 1000 Kg

i) $W = 1000g = 9800\text{ N}$

$R = W\cos\theta = 9800\cos 6^\circ$

$= 9746\text{ N}$

---

ii)

Constant speed so

$T = 2000 + W\sin 6^\circ$

$T = 2000 + 9800\sin 6^\circ$

$T = 3024\text{ N}$

---

iii)

Power $= Fv$

$= 3024 \times 16.667$

$= 50.4\text{ kW}$

---

iv)

Max speed when

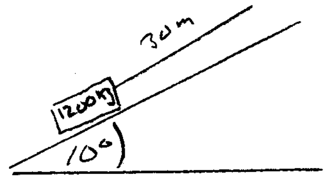
$Fv = 80\text{ kW}$

$v = \frac{80000}{3024}$

$v = 26.455\text{ m s}^{-1}$

$v = 26.455 \times \frac{3600}{1000} = 95.2\text{ km/h}$

13)



i) Work done = increase in gpe

$= 1200 \times 9.8 \times 30\sin 10^\circ$

$= 61,263\text{ J}$

$= 61,300\text{ J}$ to 3 s.f

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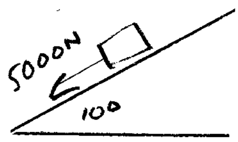
ii)

61,263 J in 120 s

Power $= \frac{61263}{120} = 511$ watts

---

iii)



Work done by winch

= work against gravity + work against resistance

$= (1200 \times 9.8\sin 10 + 5000) \times 30$

$= 211,263\text{ J}$

Power = 4500 watts

Time $= \frac{211,263}{4500} = 46.9\text{ s}$

---

iv)

Speed $= \frac{30}{46.947} = 0.639\text{ m s}^{-1}$

13iv) cont

When cable snaps

$F = -5000 - 1200 \times 9.8 \sin 10$

$= -7042\text{ N}$

$\Rightarrow$ acceleration $a = \frac{-7042}{1200}$

$a = -5.868\text{ ms}^{-2}$

Using $v^2 = u^2 + 2as$

$0 = 0.639^2 - 2 \times 5.868 s$

$\Rightarrow s = \frac{0.639^2}{2 \times 5.868}$

$s = 0.03479\text{ m}$

$s \approx 35\text{ mm}$

14)

i) At steady speed, drive force F = resistance to motion

Power $= Fv$

$5000 = F \times 2.5$

$F = \frac{5000}{2.5} = 2000\text{ N}$

Resistance to motion = 2000 N

ii) Work done by tractor

= Work against resistance + increase in ke.

$\therefore$ work against resistance

= work done by tractor − increase in KE

$= 8000 \times 10 - \frac{1}{2} 6000 (3^2 - 2.5^2)$

$= 80000 - 3000(9 - 6.25)$

$= 71{,}750\text{ J}$

Uniform acceleration so

$s = \frac{v+u}{2} \times t$

$s = \frac{3+2.5}{2} \times 10 = 27.5\text{ m}$

Work done by resistive force

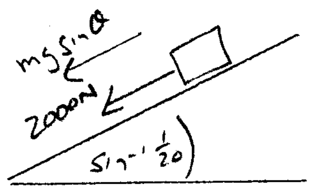
$= -71{,}750\text{ J}$ in distance 27.5 m

Resistive force $= \frac{-71{,}750}{27.5}$

$R = -2609\text{ N}$

ie. 2609 N in opposite direction to motion

iii)



$u = 3\text{ ms}^{-1}$ $v = 3.25\text{ ms}^{-1}$ $s = 100\text{ m}$

$v^2 = u^2 + 2as$

$3.25^2 = 3^2 + 2 \times 100 \times a$

14iii) cont

$$a = \frac{3.25^2 - 3^2}{200} = 7.8125 \times 10^{-3}\ ms^{-2}$$

$$v = u + at$$

$$3.25 = 3 + 7.1825 \times 10^{-3} \times t$$

$$t = \frac{3.25 - 3}{7.1825 \times 10^{-3}}$$

$$t = 32\ s$$

Work done by tractor =

work against resistance + work against gravity

$$= \left(2000 + 6000 \times 9.8 \times \tfrac{1}{20}\right) \times 100$$

$$= 494,000\ J$$

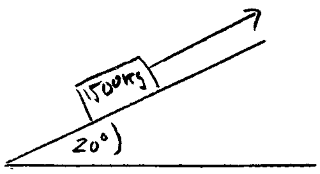
$$\text{Average Power} = \frac{494,000}{32}$$

$$= 15,437.5 \text{ watts}$$

$$\approx 15.4\ kW$$

15)

i)



$s = 25m$, $t = 50s$

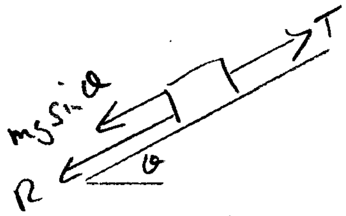
$$\Rightarrow u = \frac{25}{50} = 0.5\ ms^{-1}$$

Work done by tension in winch wire

= Power × time

$$= 6000 \times 50 = 300,000\ J$$

ii) At constant speed



$$T = R + mg\sin\theta$$

$$\Rightarrow R = T - mg\sin\theta$$

Force × dist = work done

$$\text{Now } T \times 25 = 300,000$$

$$\Rightarrow T = \frac{300,000}{25} = 12000\ N$$

$$\therefore R = 12000 - 1500 \times 9.8 \sin 20$$

$$R = 6972\ N$$

iii)

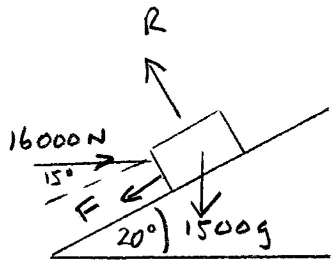
$$F_r = \mu R$$

$$\mu = \frac{F_r}{R} = \frac{6972}{mg\cos\theta}$$

$$\mu = \frac{6972}{1500 \times 9.8 \cos 20}$$

$$\mu = 0.5047 = 0.50 \text{ to 2 s.f.}$$

iv)



$$R = 1500g\cos 20 + 16000\sin 15°$$

$$R = 17955\ N$$

$$F = \mu R = 0.5 \times 17955 = 8977\ N$$

15 iv) cont

Resultant Force = ma

$16000\cos 15^\circ - F - mg\sin 20 = ma$

$16000\cos 15 - 8977 - 1500 \times 9.8\sin 20$

$= 1500a$

$1450.117 = 1500a$

$\Rightarrow a = 0.9667\ ms^{-2}$

Using $v^2 = u^2 + 2as$

$2.5^2 = 0 + 2 \times 0.9667 s$

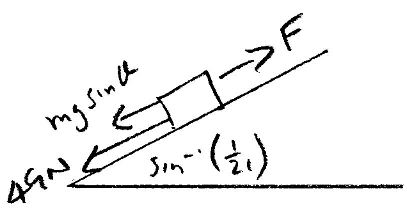
$s = \dfrac{2.5^2}{2 \times 0.9667}$

$s = 3.23$ m

16) i) Work done = Force × distance

$= 49 \times 100 = 4900$ J

ii)



At constant speed 5 ms^{-1}

$F = mg\sin\theta + 49$

$F = 84 \times 9.8 \times \frac{1}{21} + 49$

$F = 88.2$ N

Power $= Fv = 88.2 \times 5$

$= 441$ watts

iii) Power = Fv

If power is constant and v is increasing, then F must be decreasing

iv) Work done by cyclist =

work done against resistance

+ increase in K.E.

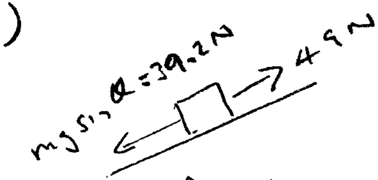
$\therefore$ work done against resistance

= work done by cyclist − increase in KE

$= 441 \times 3 - \frac{1}{2} \times 84(6^2 - 5^2)$

$= 861$ J

v)



Resultant $= 39.2 - 49$

$= -9.8$ N

$\therefore a = \dfrac{-9.8}{84} = -0.11667\ ms^{-2}$

Using $v^2 = u^2 + 2as$

$3^2 = 6^2 - 2 \times 0.11667 s$

$s = \dfrac{6^2 - 3^2}{2 \times 0.11667}$

$s = 115.7$ m

$s = 116$ m to 3 s.f.