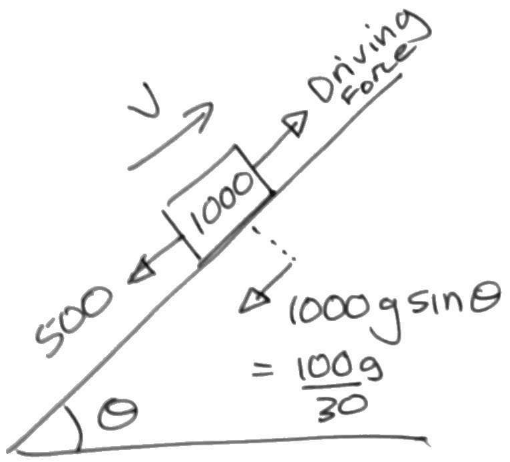
FM1 – Mechanics Chapter 2
Exam Questions: Power

Q1.

A car of mass 1000 kg moves with constant speed V m s^{-1} up a straight road inclined at an angle θ to the horizontal,

where $\sin\theta = \frac{1}{30}$. The engine of the car is working at a rate of 12 kW. The resistance to motion from non-gravitational forces has magnitude 500 N. Find the value of V.

(Total 5 marks)



constant speed
$\therefore a = 0$

$$F = ma$$

$$\text{Driving Force} - 500 - \frac{100g}{30} = 0$$

$$\text{Driving Force} = \frac{100g}{30} + 500$$

$$\text{Power} = \text{Driving Force} \times V$$

$$12000 = \left(\frac{100g}{30} + 500\right)V$$

$$V = \underline{\underline{14.5}} \text{ ms}^{-1}$$

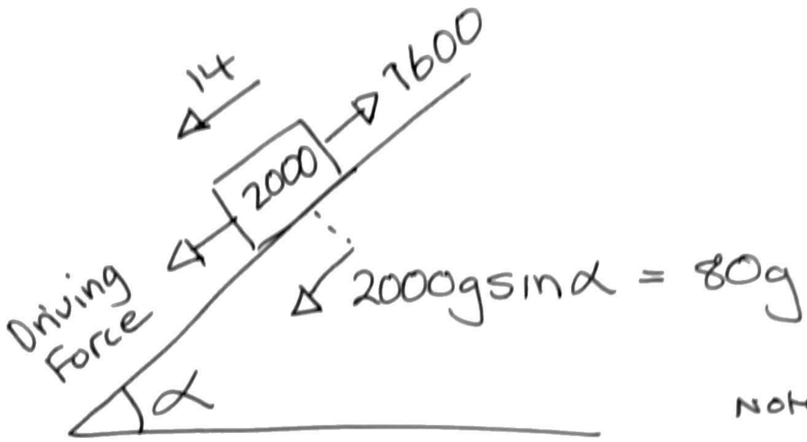
Q2.

A lorry of mass 2000 kg is moving down a straight road inclined at angle α to the horizontal, where $\sin \alpha = \frac{1}{25}$. The resistance to motion is modelled as a constant force of magnitude 1600 N. The lorry is moving at a constant speed of 14 m s^{-1}.

Find, in kW, the rate at which the lorry's engine is working.

(6)

(Total 6 marks)



Note: constant speed
$\therefore a = 0$

$$\text{Driving Force} + 80g = 1600$$

$$= 1600 - 80g$$

$$\text{Power} = (1600 - 80g)14$$

$$= 11{,}424$$

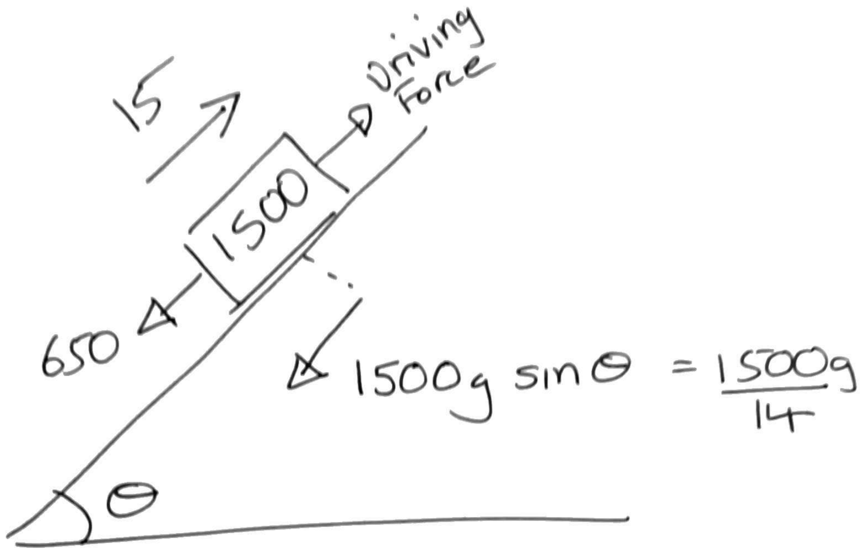
$$= \underline{\underline{11.4\text{kW}}}$$

Q3.

A car of mass 1500 kg is moving up a straight road, which is inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{14}$. The resistance to the motion of the car from non-gravitational forces is constant and is modelled as a single constant force of magnitude 650 N. The car's engine is working at a rate of 30 kW. Find the acceleration of the car at the instant when its speed is 15 m s^{-1}.

(5)

(Total 5 marks)



Power = Driving Force × V

$30\,000 = D \times 15$

$D = 2000$

$F = ma$

$2000 - 650 - \frac{1500g}{14} = 1500a$

$a = \underline{\underline{0.2}}\ \text{ms}^{-2}$

Q4

A truck of mass of 300 kg moves along a straight horizontal road with a constant speed of 10 m s^{-1}. The resistance to motion of the truck has magnitude 120 N.

(a) Find the rate at which the engine of the truck is working.

(2)

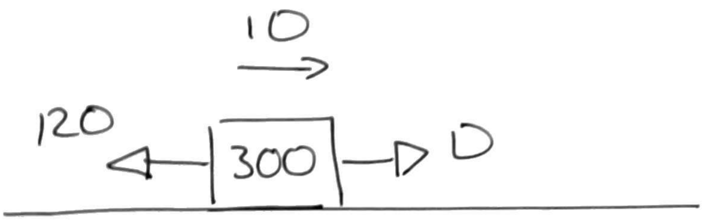
On another occasion the truck moves at a constant speed up a hill inclined at θ to the horizontal, where $\sin\theta = \frac{1}{14}$. The resistance to motion of the truck from non-gravitational forces remains of magnitude 120 N. The rate at which the engine works is the same as in part (a).

(b) Find the speed of the truck.

(4)

(Total 6 marks)

(a)



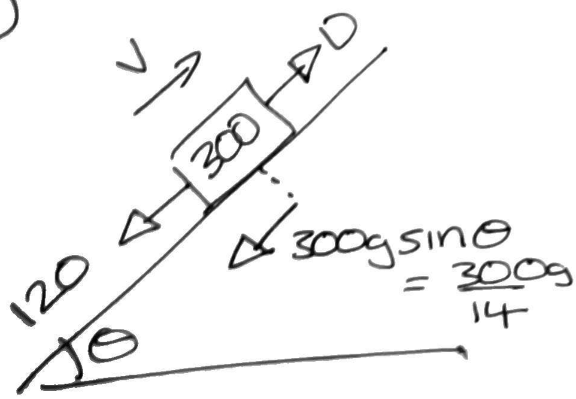
constant speed

$\therefore a = 0$

$\therefore D = 120$

$$\text{Power} = \text{Driving Force} \times V$$
$$= 120 \times 10$$
$$= \underline{\underline{1200\text{ W}}}$$

(b)



$$\text{Power} = D \times V$$
$$30\,000 = \left(120 + \frac{300g}{14}\right) \times V$$
$$30000 = 330V$$
$$V = \underline{\underline{3.6\text{ ms}^{-1}}}$$

Q5

A caravan of mass 600 kg is towed by a car of mass 900 kg along a straight horizontal road. The towbar joining the car to the caravan is modelled as a light rod parallel to the road. The total resistance to motion of the car is modelled as having magnitude 300 N. The total resistance to motion of the caravan is modelled as having magnitude 150 N. At a given instant the car and the caravan are moving with speed 20 m s^{-1} and acceleration 0.2 m s^{-2}.

(a) Find the power being developed by the car's engine at this instant.

(5)

(b) Find the tension in the towbar at this instant.

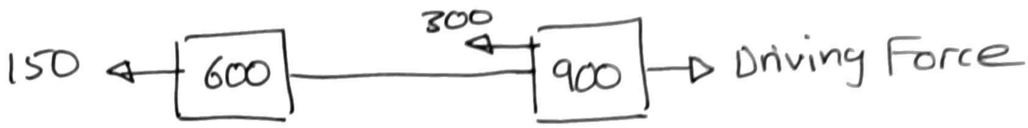
(2)

(Total 7 marks)

$20\text{ ms}^{-1} \rightarrow$

$a = 0.2$

(a)



$F = ma$

$D - 450 = 1500(0.2)$

$D = 750$

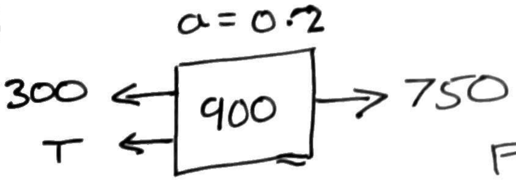
$\text{Power} = D \times V$

$= 750 \times 20$

$= 15{,}000 \text{ watts}$

$= \underline{\underline{15 \text{ kW}}}$

(b)



$F = ma$

$750 - 300 - T = 900(0.2)$

$450 - T = 180$

$T = \underline{\underline{270 \text{ N}}}$

Q6

A car of mass 750 kg is moving up a straight road inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{15}$. The resistance to motion of the car from non-gravitational forces has constant magnitude R newtons. The power developed by the car's engine is 15 kW and the car is moving at a constant speed of 20 m s^{-1}.

(a) Show that $R = 260$.

(4)

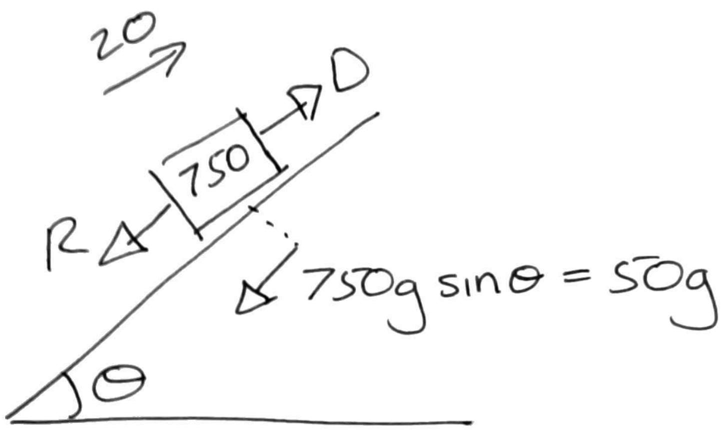
The power developed by the car's engine is now increased to 18 kW. The magnitude of the resistance to motion from non-gravitational forces remains at 260 N. At the instant when the car is moving up the road at 20 m s^{-1} the car's acceleration is a m s^{-2}.

(b) Find the value of a.

(4)

(Total 8 marks)

(a)



$$\text{Power} = D \times V$$

$$15000 = D \times 20$$

$$D = 750$$

$$F = ma$$

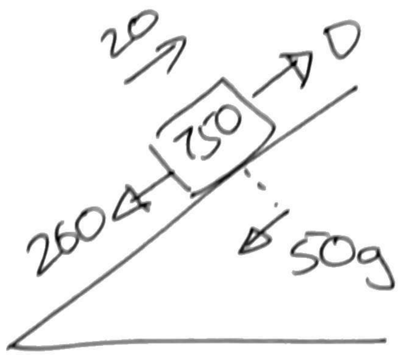
constant speed

$$750 - R - 50g = 750(0)$$

$$R = 750 - 50g$$

$$R = \underline{\underline{260}}$$

(b)



$$\text{Power} = D \times v$$

$$18\,000 = D \times 20$$

$$D = 900$$

$$F = ma$$

$$900 - 260 - 50g = 750(a)$$

$$a = \underline{\underline{0.2}}\ ms^{-2}$$

Q7.

A car of mass 1200 kg pulls a trailer of mass 400 kg up a straight road which is inclined to the horizontal at an angle a, where

$\sin a = \frac{1}{14}$. The trailer is attached to the car by a light inextensible towbar which is parallel to the road. The car's engine works at a constant rate of 60 kW. The non-gravitational resistances to motion are constant and of magnitude 1000 N on the car and 200 N on the trailer.

At a given instant, the car is moving at 10 m s^{-1}. Find

(a) the acceleration of the car at this instant,

(5)

(b) the tension in the towbar at this instant.

(4)

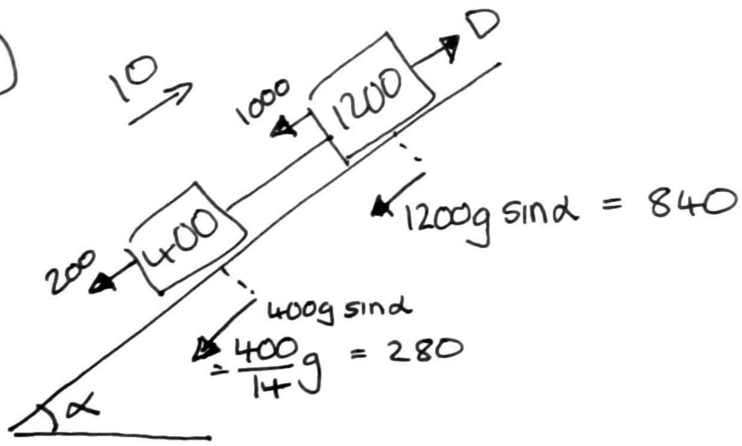
The towbar breaks when the car is moving at 12 m s^{-1}.

(c) Find, using the work-energy principle, the further distance that the trailer travels before coming instantaneously to rest.

(5)

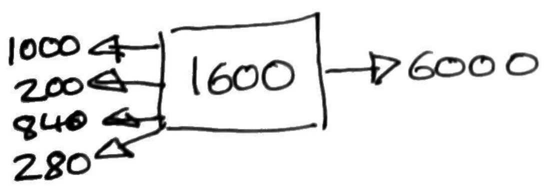
(Total 14 marks)

(a)



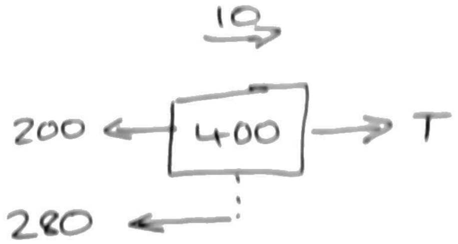
$$\text{Power} = D \times V$$
$$60000 = D \times 10$$
$$D = 6000$$

$$F = ma$$



$$6000 - 1000 - 200 - 840 - 280 = 1600a$$
$$a = \underline{\underline{2.3\ \text{ms}}}$$

(b)

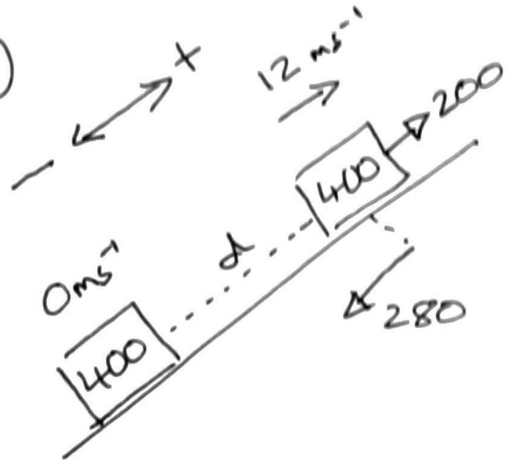


$$F = ma$$

$$T - 200 - 280 = 400(2.3)$$

$$T = \underline{\underline{1400\,N}}$$

(c)



$d \sin\alpha$
$= \frac{d}{14}$

Initial Energy = Final Energy

Work In + KE + PE = Work out + KE + PE

$$0 + \frac{1}{2}(400)(12)^2 + 400(-9.8)\frac{d}{14} = d \times 200 + 0 + 0$$

$$28\,800 - 280d = 200d$$

$$d = \frac{28\,800}{480}$$

$$d = \underline{\underline{60\text{ m}}}$$

Q8

A car of mass 800kg is moving on a straight road which is inclined at an angle θ to the horizontal, where $\sin\theta = \dfrac{1}{20}$. The resistance to the motion of the car from non-gravitational forces is modelled as a constant force of magnitude R newtons. When the car is moving up the road at a constant speed of 12.5ms^{-1}, the engine of the car is working at a constant rate of $3P$ watts. When the car is moving down the road at a constant speed of 12.5ms^{-1}, the engine of the car is working at a constant rate of P watts.

(a) Find

(i) the value of P,
(ii) the value of R.

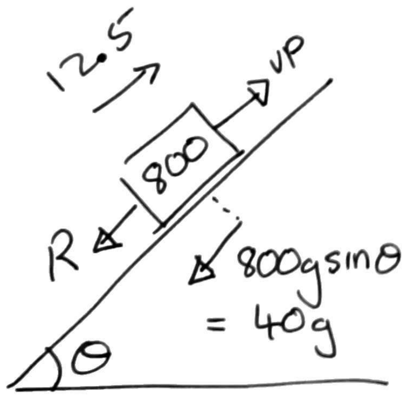
(6)

When the car is moving up the road at 12.5ms^{-1} the engine is switched off and the car comes to rest without braking, in a distance d metres. The resistance to the motion of the car from non-gravitational forces is still modelled as a constant force of magnitude R newtons.

(b) Use the work-energy principle to find the value of d.

(Total for question = 10 marks)

(a)

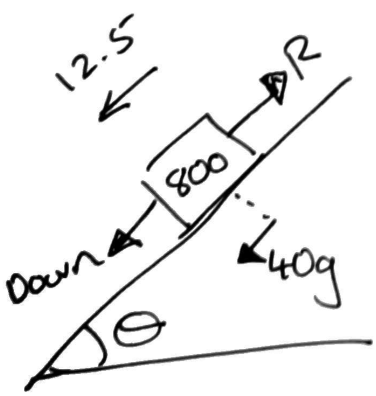


UP constant speed $\therefore a = 0$

$F = ma$

$UP - R - 40g = 800(0)$

$UP = R + 40g$



DOWN constant speed $\therefore a = 0$

$F = ma$

$Down - R + 40g = 800(0)$

$Down = R - 40g$

UP

Power = Up × v

$3p = UP(12.5)$

Down

Power = Down × v

$P = Down(12.5)$

$$3(Down(12.5)) = UP(12.5)$$

$$3\,Down = UP$$

$$3(R - 40g) = R + 40g$$

$$3R - 120g = R + 40g$$

$$2R = 160g$$

$$R = \underline{\underline{80g}}$$

$$P = Down(12.5)$$

$$P = (R - 40g)(12.5)$$

$$P = (80g - 40g)(12.5)$$

$$P = 40g(12.5)$$

$$P = \underline{\underline{500g}}$$