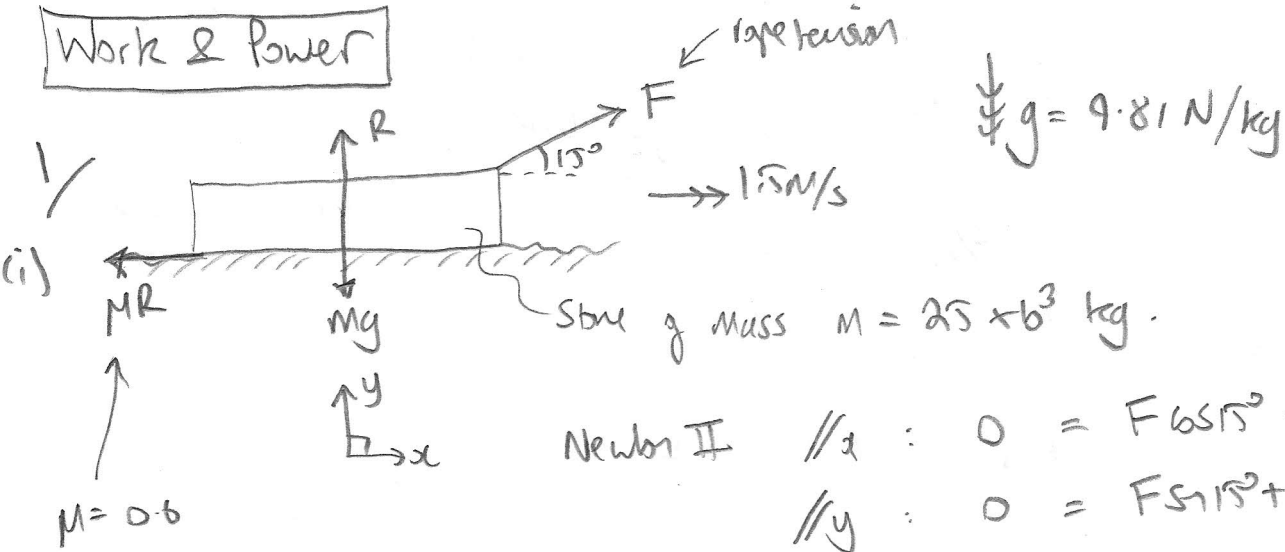


Work & Power



Newton II // x : $0 = F \cos 15^\circ - MR$ (1)

// y : $0 = F \sin 15^\circ + R - mg$ (2)

Dynamic equilibrium since moving at constant speed.

Work done per second is $\boxed{F \cos 15^\circ \times 1.5 \text{ m/s}}$, so need to find F .

(1) $R = \frac{F \cos 15^\circ}{\mu}$

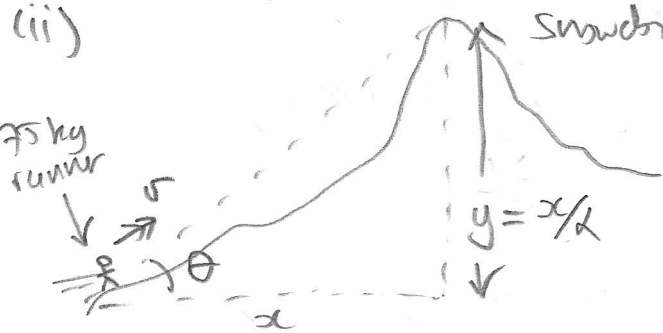
in (2): $F \sin 15^\circ + \frac{F \cos 15^\circ}{\mu} = mg$

$\therefore F \left(\sin 15^\circ + \frac{\cos 15^\circ}{\mu} \right) = mg$

$$\begin{aligned} \therefore F \cos 15^\circ \times 1.5 &= \frac{mg \cos 15^\circ \times 1.5}{\sin 15^\circ + \frac{\cos 15^\circ}{0.6}} \\ &= \frac{25 \times 10^3 \times 9.81 \times \cos 15^\circ \times 1.5}{\sin 15^\circ + \frac{\cos 15^\circ}{0.6}} \\ &= \boxed{190 \text{ kW}} \end{aligned}$$

$(1.90 \times 10^5 \text{ J/s})$.

(ii)



$g = 9.81 \text{ N/kg}$
 $y = 965 \text{ m}$

(Not too scale!)

gradient $\alpha = 7.1$ (ie "1 in 7.1")

Rate of work done against gravity is $P = \frac{mgy}{t}$
 $= \frac{75 \text{ kg} \times 9.81 \text{ N/kg} \times 965 \text{ m}}{40 \times 60 \text{ s}} = 296 \text{ W}$

Distance travelled is $\sqrt{x^2 + \frac{x^2}{7.1^2}}$, so speed // slope

ie: $v = \frac{x \sqrt{1 + \frac{1}{7.1^2}}}{t}$ and $x = 7.1 \times 965 \text{ m}$

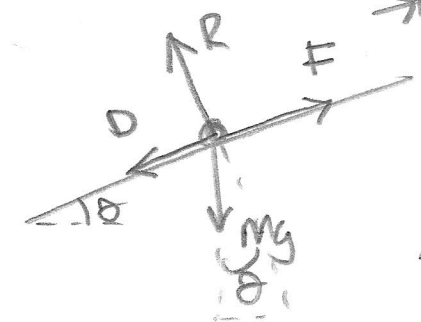
ie $v = \frac{7.1 \times 965 \sqrt{1 + \frac{1}{7.1^2}}}{40 \times 60 \text{ s}} = 2.88 \text{ m/s}$

If driving force // slope is F , $Fv =$ rate of work done against gravity if drag and friction can be ignored.

$\therefore F = \frac{296 \text{ W}}{2.88 \text{ m/s}} = 103 \text{ N}$

[Note Since in eq we can also compute the net resistive force D // slope.

$\rightarrow 2.88 \text{ m/s} \leftarrow$ ie, not accelerating.



Net // to slope:

$F = D + Mg \sin \theta$

$\therefore D = 103 - 75 \times 9.81 \times \sin(\tan^{-1}(\frac{1}{7.1})) \approx 0 \text{ N}$

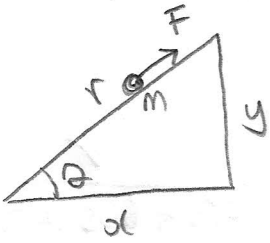
• = runner
(1)

2

This is exactly what we would expect if $F \times \text{slope distance}$ equates to the GPE change. If there are additional resistive forces, then $F \times \text{slope distance}$ must account for work done against these forces as well as gravity.

Additional note:

a slope provides a Mechanical advantage



$\#g$ let $F r = m g y$ ie work done pushing particle of mass m up a slope = GPE change.

Now $r = \sqrt{x^2 + y^2}$ and let $\alpha = x/y$ where gradient is "1 in α ".

$$r = y \sqrt{1 + \alpha^2}$$

$$F y \sqrt{1 + \alpha^2} = m g y$$

$$F = \frac{m g}{\sqrt{1 + \alpha^2}}$$

so $\sqrt{1 + \alpha^2}$ is the mechanical advantage, ie what we can divide the weight by to get the pushing force F . A vertical slope means $\alpha \rightarrow 0 \Rightarrow F = m g$

ie no mechanical advantage at all.

