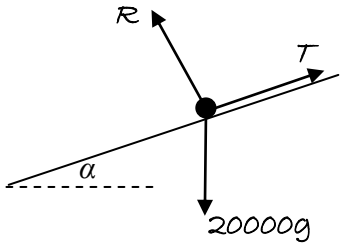
Section 2: Newton's second law

Solutions to Exercise level 3

1. (i)



$\tan\alpha = \frac{1}{3.8} = \frac{5}{19}$

$\alpha = 14.743...$

Resolving up the slope: $T - 20000g\sin\alpha = 0$

$T = 20000 \times 9.8 \times \sin\alpha = 49880...$

Force in cable = 49900 N (3 s.f.)

(ii) Resolving perpendicular to the slope: $R - 20000g\cos\alpha = 0$

$R = 20000 \times 9.8 \times \cos\alpha = 189546...$

Normal reaction force = 190000 N (3 s.f.)

(iii) Resolving down the slope: $mg\sin\alpha = ma$

$a = 9.8 \times \sin\alpha = 2.494...$

Acceleration = 2.49 ms^{-2} (3 s.f.)

After 100m, $u = 0, s = 100, a = 2.494, v = ?$

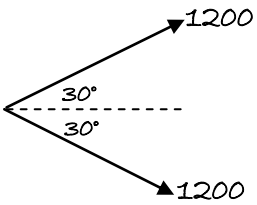
$v^2 = u^2 + 2as$

$= 0 + 2 \times 2.494 \times 100$

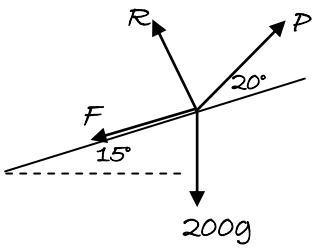
$v = 22.33..$

Speed = 22.3 ms^{-1}.

2. (i) Top view



Side view



The resultant of the two pulling forces, $P = 2 \times 1200\cos 30° = 1200\sqrt{3}$

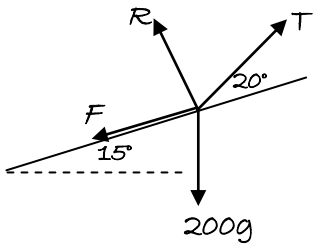
Resolving up the plane: $P\cos 20° - 200g\sin 15° - F = 0$

$F = 1200\sqrt{3}\cos 20° - 200g\sin 15°$

$F = 1445.8...$

The resistance is 1450 N (3 s.f.)

(ii)



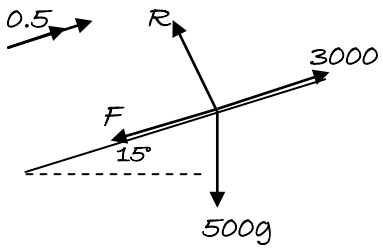
Resolving up the plane: $T\cos 20° - 200g\sin 15° - F = 0$

$$T = \frac{200g\sin 15° + 1445.8...}{\cos 20°}$$

$$T = 2078.46...$$

The force required is 2080 N (3 s.f.)

3. (i)



Resolving up the slope: $3000 - 500g\sin 15° - F = 500 \times 0.5$

$$F = 3000 - 500g\sin 15° - 500 \times 0.5$$

$$F = 1481.78...$$

Resistance force = 1480 N (3 s.f.)

(ii) Resolving up the slope: $-F - 500g\sin 15° = 500a$

$$500a = -1481.78... - 500g\sin 15°$$

$$a = -5.5$$

$v = u + at$

$0 = 0.75 - 5.5t$

$t = 0.1363...$

so it takes 0.14 seconds to stop (2 s.f.)

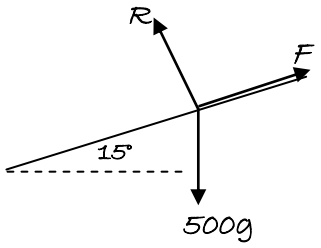
$v^2 = u^2 + 2as$

$0 = 0.75^2 - 2 \times 5.5s$

$s = 0.05113...$

so it travels 5.1 cm (2 s.f.)

(iii) The resistance force is now acting up the slope:



The component of the weight acting down the slope is

$500g\sin 15° = 1268.2...$

This is less than the resistance force, so it will not slide.

(iv) Resistance is now 0.2 × its previous value

Resolving up the slope: $-F - 500g\sin 15° = 500a$

$500a = 0.2 \times -1481.78... - 500g\sin 15°$

$a = -3.129...$

$t = \dfrac{0.75}{3.129} = 0.23968...$

Time taken to stop = 0.24 s (2 s.f.)

Moving downwards:

$500g\sin 15° - F = 500a$

$500a = 500g\sin 15° - 0.2 \times 1481.78...$

$a = 1.9437...$

$v = u + at$

$0.75 = 0 + 1.9437t$

$t = 0.3858...$

so it takes 0.39 seconds (2 d.p.)