Exercise 4A

1 Work done $= Fs$
$= 0.6 \times 4.2$
$= 2.52$
The work done is 2.52 J

2 Work done $= Fs$
$102 = F \times 12$
$F = \frac{102}{12} = 8.5$
The magnitude of the force is 8.5 N

3 Work done against gravity $= mgh$
$= 0.35 \times 9.8 \times 7$
$= 24.01$
The work done against gravity is 24.0 J (3 s.f.)

4 Work done against gravity $= mgh$
$= 15 \times 9.8 \times 4$
$= 588$
The work done against gravity is 588 J

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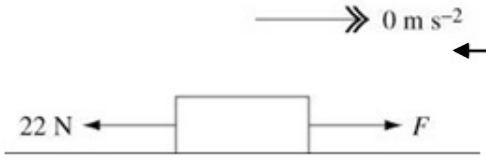

No acceleration, so the force pushing the box has the same magnitude as the resistances.

$F = 22$ N

Work done $= Fs$
$= 22 \times 15$
$= 330$
The work done by the force pushing the box is 330 J

6 Work done by gravity $= mgh$
$= 0.5 \times 9.8 \times 15$
$= 73.5$
The work done by gravity is 73.5 J

7 Work done $= mgh$

$30 \times 1000 = 80 \times 9.8h$ ← 1 kJ = 1000 J

$$h = \frac{30000}{80 \times 9.8}$$

$h = 38.26\ldots$

The building is 38.3 m high (3 s.f.)

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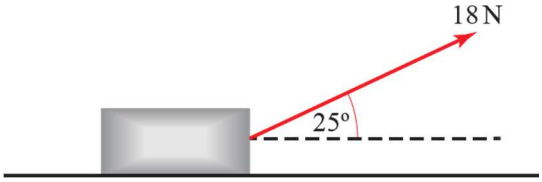

Work done = horizontal component of force × distance moved

$= 18\cos 25° \times 14$

$= 228.38\ldots$

The work done is 228 J (3 s.f.)

b One assumption made is that there is no frictional force between the sled and the ice.
This is likely to be a valid assumption, due to the low coefficient of friction between sled and ice.

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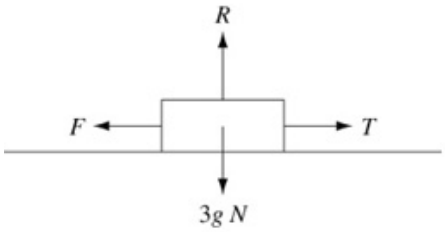

Work done $= Ts$

$30 = T \times 4$

$T = 7.5$

Resolving parallel to the plane: ← The parcel moves at a constant speed so the acceleration is 0 m s^{-2}

$T - F = 0$

$7.5 - F = 0$

$F = 7.5$

Resolving perpendicular to the plane to find R.

$R = mg$

$R = 3 \times 9.8$

Friction is limiting:

$F = \mu R$

$7.5 = \mu \times 3 \times 9.8$

$$\mu = \frac{7.5}{3 \times 9.8} = 0.2551\ldots$$

The coefficient of friction is 0.255 (3 s.f.)

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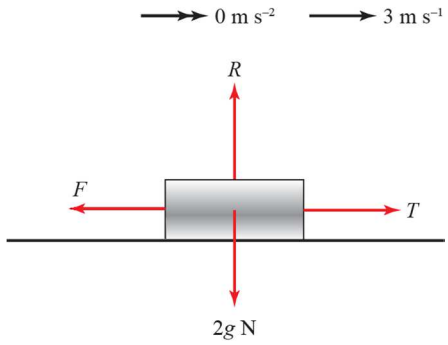
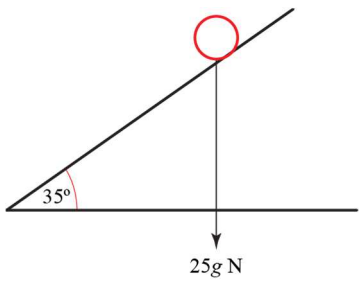


$\mu = 0.55$

Resolving perpendicular to the plane:
$R = 2g$
Friction is limiting:
$F = \mu R$
$F = 0.55 \times 2g$
Resolving parallel to the plane:
$T - F = 0$
$T = 0.55 \times 2g$
Work done $= Ts$
$= 0.55 \times 2g \times (3 \times 2)$ ← Distance moved = speed × time
$= 0.55 \times 2 \times 9.8 \times 6$
$= 64.68$
The work done is 64.7 J (3 s.f.)

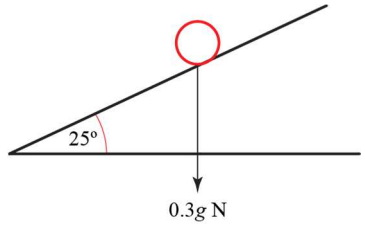
11 Work done against gravity $= mgh$
$= 52 \times 9.8 \times 46$
$= 23\ 441.6$
The work done against gravity is 23 400 J (3 s.f.)

12



Work done by gravity $= mgh$
$= 25 \times 9.8 \times (2 \sin 35°)$ ← Vertical distance moved = 2 sin 35°
$= 281.0\ldots$
The work done by gravity is 281 J (3 s.f.)

13



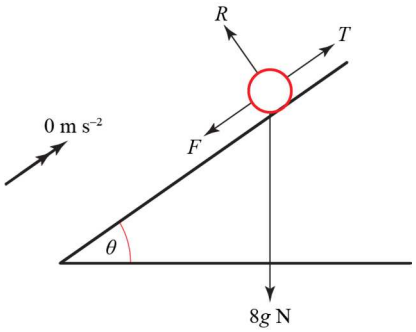
Work done against gravity $= mgh$

$= 0.3 \times 9.8 \times (2\sin 25°)$

$= 2.484\ldots$

The work done against gravity is 2.48 J (3 s.f.)

14



$\mu = 0.3$

a Resolving perpendicular to the plane:

$R = 8g\cos\alpha$

$= 8g \times \frac{12}{13}$

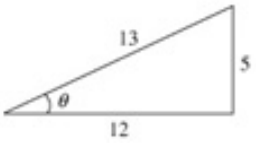
Friction is limiting:

$F = \mu R$

$F = 0.3 \times 8 \times 9.8 \times \frac{12}{13}$

$= 21.71\ldots$

The frictional force has magnitude 21.7 N (3 s.f.)



Draw a small right-angled triangle to show information about α. Use exact values for $\sin\alpha$ and $\cos\alpha$.

b Work done against friction $= Fs$

$= 21.71\ldots \times 15$

$= 325.6\ldots$

The work done against friction is 326 J (3 s.f.)

c Work done against gravity $= mgh$

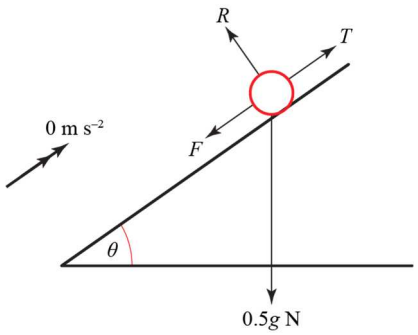
$= 8 \times 9.8 \times (15\sin\alpha)$

$= 8 \times 9.8 \times \left(15 \times \frac{5}{13}\right)$

$= 452.3\ldots$

The work done against gravity is 452 J (3 s.f.)

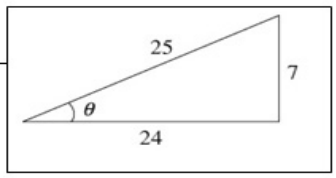
15



Resolving perpendicular to the plane:

$R = 0.5g\cos\theta$

$= 0.5g \times \frac{24}{25}$



Resolving parallel to the plane:

$T = F + 0.5g\sin\theta$

Friction is limiting:

$F = \mu R$

$F = \mu \times 0.5g \times \frac{24}{25}$

$T = \mu \times 0.5g \times \frac{24}{25} + 0.5g \times \frac{7}{25}$

Work done by force = force × distance moved

$12 = T \times 3$

$T = 4$

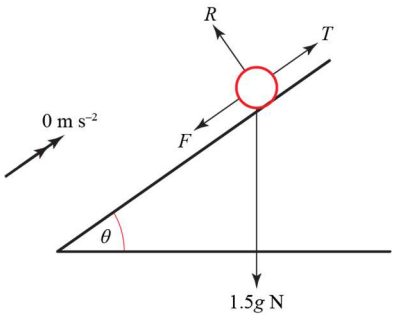
$\therefore \quad 4 = \mu \times 0.5g \times \frac{24}{25} + 0.5g \times \frac{7}{25}$

$$\mu = \frac{4 - 0.5 \times 9.8 \times \frac{7}{25}}{0.5 \times 9.8 \times \frac{24}{25}}$$

$\mu = 0.5586\ldots$

The coefficient of friction is 0.559 (3 s.f.)

16



$\mu = 0.4$

Resolving perpendicular to the plane:

$R = 1.5g\cos 40°$

Friction is limiting:

$F = \mu R$

$F = 0.4 \times 1.5g\cos 40°$

Resolving parallel to the plane:

$T = F + 1.5g\sin 40°$

$T = 0.4 \times 1.5g\cos 40° + 1.5g\sin 40°$

Work done by $T = T \times s$

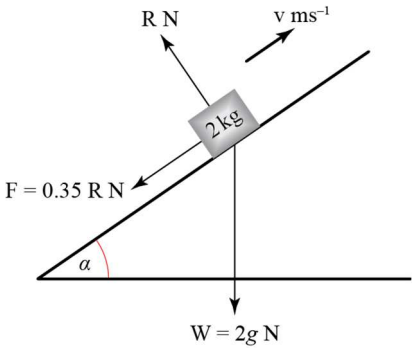
$= (0.4 \times 1.5g\cos 40° + 1.5g\sin 40°) \times 8$

$= 111.6\ldots$

The work done by T is 112 J (3 s.f.)

17 $\sin\alpha = \frac{3}{5} \Rightarrow \cos\alpha = \frac{4}{5}$

Work done = force × distance moved in direction of force



a Work done by gravity $E_g = Wh$

Weight, $W = mg = 2g$, $h = 3\sin\alpha = \frac{9}{5}$ m

$E_g = 2g \times \frac{9}{5}$

$E_g = 2 \times 9.8 \times 1.8 = 35.28$

The work done by gravity is 35.3 J (3 s.f.)

b Work done by friction $E_F = Fs$, $s = 3$ m

Normal reaction force, R, can be found by resolving perpendicular to the slope:

$R = 2g\cos\alpha$

$R = \frac{8}{5}g$

So frictional force, $F = \frac{7}{20} \times \frac{8}{5}g = \frac{14}{25}g$

$E_F = \frac{14}{25}g \times 3$

$E_F = 0.56 \times 9.8 \times 3 = 16.464$

The work done by gravity is 16.5 J (3 s.f.)

17 c Work done against these forces = kinetic energy lost

Since kinetic energy = $\frac{1}{2}mv^2$, so here:

$$35.28+16.464=\left(\frac{1}{2}\times 2u^2\right)-\left(\frac{1}{2}\times 2\times 0^2\right)$$

$$51.744=u^2$$

$$u=7.1933...$$

The particle is projected at a speed of 7.19 m s^{-1} (3 s.f.)