6.52

Var	Given value	Units	Description
PE_{i}		J	initial potential energy
m	30.	kg	mass
g	9.80	$\frac{\mathrm{m}}{\mathrm{s}^2}$	Acceleration due to gravity
h	1000.	m	drop height
KE_{f}		J	final kinetic energy
v		$\frac{\mathrm{m}}{\mathrm{s}}$	Velocity

$$PE_{\mathrm{i}} = m\,g\,h$$

$$= (30.\,\mathrm{kg})\left(9.80\,\frac{\mathrm{m}}{\mathrm{s}^2}\right)(1000.\,\mathrm{m})$$

$$= 2.9\times10^{5}\,\mathrm{J} \quad \checkmark$$

90% of initial PE lost so 10% remains to become KE.

$$KE_{\mathrm{f}} = 0.1\,PE_{\mathrm{i}}$$

$$= 0.1\left(2.9\times10^{5}\,\mathrm{J}\right)$$

$$= 3.\times10^{4}\,\mathrm{J} \quad \checkmark$$

6.52 (continued)

$$KE_{\mathrm{f}} = \frac{1}{2} m v^2$$

$$v = \sqrt{\frac{2\,KE_{\mathrm{f}}}{m}}$$

$$= \sqrt{\frac{2\left(3.\times 10^{4}\ \mathrm{J}\right)}{30.\mathrm{kg}}}$$

$$= 40\,\frac{\mathrm{m}}{\mathrm{s}}$$ ✔

6.54

Var	Given value	Units	Description
$work$		J	work
F	20.0	N	force along direction of displacement
Δx	4.0	m	displacement
W_x		N	component of weight along incline
m	4.0	kg	mass
g	9.80	$\frac{m}{s^2}$	Acceleration due to gravity
θ		°	angle of incline
h	1.5	m	height of incline

$$work = F\,\Delta x$$

$$= (20.\,\mathrm{N})(4.0\,\mathrm{m})$$

$$= 80.\,\mathrm{J}$$

How much of the force must overcome the component of the weight along the incline?

$$\sin\theta = \frac{h}{\Delta x}$$

$$W_x = m\,g\sin\theta$$

6.54 (continued)

$$W_x = m g \frac{h}{\Delta x}$$

$$= (4.0\,\mathrm{kg})\left(9.80\,\frac{\mathrm{m}}{\mathrm{s}^2}\right)\frac{1.5\,\mathrm{m}}{4.0\,\mathrm{m}}$$

$$= 15.\,\mathrm{N}$$ ✓

So 15 N is required to overcome gravity. The remainder of the force must overcome friction if 20 N is the minimum force required to pull the block up the hill.

Var	Given value	Units	Description
$work_f$		J	work against friction
f		N	friction

$$f = F - W_x$$

$$= (20.\,\mathrm{N}) - (15.\,\mathrm{N})$$

$$= 5\,\mathrm{N}$$ ✓

$$work_f = f\,\Delta x$$

$$= (5\,\mathrm{N})(4.0\,\mathrm{m})$$

6.54 (continued)

$$= 20\,\mathrm{J}$$

$$\%\ lost = \frac{20\ J}{80\ J} X 100\ \% = 25\ \%$$

6.56

Var	Given value	Units	Description
$work_{fric}$		J	work against friction
KE_f	0	J	final kinetic energy
KE_i		J	initial kinetic energy
f		N	friction
d		m	stopping distance
m		kg	mass
v		$\frac{m}{s}$	initial velocity
μ			coefficient of friction
g	9.80	$\frac{m}{s^2}$	Acceleration due to gravity

$$work_{fric} = KE_i$$

$$f\,d = \frac{1}{2}\,m\,v^2$$

$$\mu\,m\,g\,d = \frac{1}{2}\,m\,v^2$$

$$\mu\,g\,d = \frac{1}{2}\,v^2$$

$$d = \frac{v^2}{2\,\mu\,g}$$

6.58

Var	Given value	Units	Description
ΔPE		J	change in potential energy of system
m_5	5.0	kg	mass of hanging block
g	9.80	$\frac{m}{s^2}$	Acceleration due to gravity
Δh	1.0	m	change in height of hanging block (also distance other block moves on table)
$work_{fric}$		J	work against friction by system
f		N	friction on block on table
g	9.80	$\frac{m}{s^2}$	Acceleration due to gravity
μ	0.28		coefficient of friction
m_2	2.0	kg	mass of block on table

Only the hanging block's potential energy changes, so the change in potential energy of the whole system (both blocks) is given by

$$\Delta PE = m_5 g \Delta h$$

$$= (5.0\,\text{kg})\left(9.80\,\frac{\text{m}}{\text{s}^2}\right)(1.0\,\text{m})$$

$$= 49.\,\text{J}$$

6.58 (continued)

Work against friction by the system is found by multiplying the frictional force on the block on the table by the distance it moves (which is the same as the drop height of the hanging block)

$$f = \mu m_2 g$$

$$= (0.28)(2.0\,\text{kg})\left(9.80\,\frac{\text{m}}{\text{s}^2}\right)$$

$$= 5.5\,\text{N}$$

$$work_{\text{fric}} = f\Delta h$$

$$= (5.5\,\text{N})(1.0\,\text{m})$$

$$= 5.5\,\text{J}$$

In a frictionless situation, the change in potential energy of the system would be equal to the change in kinetic energy of the system. Since we have friction, however, we must subtract the work done against friction from the change in potential energy. This "leftover" energy goes towards the change in kinetic energy of both blocks (note that we use the total mass in the kinetic energy formula since both blocks are moving).

Var	Given value	Units	Description
ΔKE_{sys}		J	change in kinetic energy of both blocks
v		$\frac{\text{m}}{\text{s}}$	velocity of blocks

$$\Delta KE_{\text{sys}} = \Delta PE_5 - work_{\text{fric}}$$

6.58 (continued)

$$= (49.\,\mathrm{J}) - (5.5\,\mathrm{J})$$

$$= 43.\,\mathrm{J}$$

$$\Delta KE_{\mathrm{sys}} = \frac{1}{2}(m_2 + m_5)\,v^2$$

$$2\,\Delta KE_{\mathrm{sys}} = (m_2 + m_5)\,v^2$$

$$\frac{2\,\Delta KE_{\mathrm{sys}}}{m_2 + m_5} = v^2$$

$$v = \sqrt{\frac{2\,\Delta KE_{\mathrm{sys}}}{m_2 + m_5}}$$

$$= \sqrt{\frac{2\,(43.\,\mathrm{J})}{(2.0\,\mathrm{kg}) + (5.0\,\mathrm{kg})}}$$

$$= 3.5\,\frac{\mathrm{m}}{\mathrm{s}}$$