6.40

At the top, the egg has gravitational potential energy and at 0.50 m from the ground, it has both potential and kinetic energy. According to conservation of energy, the total energy at these two points is a constant.

Var	Given value	Units	Description
PE_i		J	gravitational potential energy at top
KE_f		J	final kinetic energy
PE_f		J	final potential energy
m		kg	mass of object
g	9.80	$\frac{m}{s^2}$	acc. due to grav.
h_i	3.0	m	initial height
h_f	0.50	m	final height
v_f		$\frac{m}{s}$	final velocity

$$PE_i = KE_f + PE_f$$

$$m g h_i = \frac{1}{2} m v_f^2 + m g h_f$$

$$g h_i = \frac{1}{2} v_f^2 + g h_f$$

$$g(h_i - h_f) = \frac{1}{2} v_f^2$$

6.40 (continued)

$$v_f = \sqrt{2g(h_i - h_f)}$$

$$= \sqrt{2\left(9.80\,\frac{\text{m}}{\text{s}^2}\right)\left((3.0\,\text{m}) - (0.50\,\text{m})\right)}$$

$$= 7.0\,\frac{\text{m}}{\text{s}}$$ ✓

6.42

Var	Given value	Units	Description
KE_i		J	initial kinetic energy
KE_f		J	kinetic energy just before roof
PE_f		J	potential energy at roof
m		kg	mass og ball
v_i	12.3	$\frac{m}{s}$	initial velocity
v_f		$\frac{m}{s}$	velocity just before roof
g	9.80	$\frac{m}{s^2}$	acc. due to gravity
h	5.42	m	height of roof

$$KE_i = KE_f + PE_f$$

$$\frac{1}{2} m v_i^2 = \frac{1}{2} m v_f^2 + m g h$$

$$\frac{1}{2} v_i^2 = \frac{1}{2} v_f^2 + g h$$

$$\frac{1}{2} v_i^2 - g h = \frac{1}{2} v_f^2$$

$$2\left(\frac{1}{2} v_i^2 - g h\right) = v_f^2$$

$$v_f = \sqrt{v_i^2 - 2 g h}$$

6.42 (continued)

$$= \sqrt{\left(12.3\,\frac{\text{m}}{\text{s}}\right)^2 - 2\left(9.80\,\frac{\text{m}}{\text{s}^2}\right)(5.42\,\text{m})}$$

$$= 6.7\,\frac{\text{m}}{\text{s}}$$

6.44

The initial kinetic energy is equal to the potential energy at the maximum height.

Var	Given value	Units	Description
PE_{max}		J	potential energy at maximum height
m		kg	mass
h_{max}	9.0	m	maximum height
g	9.80	$\frac{m}{s^2}$	Acceleration due to gravity
KE_8		J	kinetic energy at 8 m
PE_8		J	potential energy at 8 m
v_8		$\frac{m}{s}$	velocity at 8 m
h_8	8.0	m	height at 8 m

$$PE_{max} = KE_8 + PE_8$$

$$m g h_{max} = \frac{1}{2} m v_8{}^2 + m g h_8$$

$$g h_{max} = \frac{1}{2} v_8{}^2 + g h_8$$

$$g h_{max} = \frac{1}{2} v_8{}^2 + g h_8$$

$$g(h_{max} - h_8) = \frac{1}{2} v_8{}^2$$

6.44 (continued)

$$v_8 = \sqrt{2g(h_{max} - h_8)}$$

$$= \sqrt{2\left(9.80\,\frac{m}{s^2}\right)\left((9.0\,m) - (8.0\,m)\right)}$$

$$= 4.4\,\frac{m}{s}$$

6.46

Var	Given value	Units	Description
KE_i		J	initial kinetic energy
PE_i		J	initial potential energy
KE_f	293	J	final kinetic energy
PE_f		J	final potential energy
m		kg	
v_i	15.7	$\frac{m}{s}$	
h_i	12.7	m	
h_f	1.29	m	
g	9.80	$\frac{m}{s^2}$	Acceleration due to gravity

$$KE_i + PE_i = KE_f + PE_f$$

$$\frac{1}{2} m v_i^2 + m g h_i = KE_f + m g h_f$$

$$m\left(\frac{1}{2} v_i^2 + g h_i - g h_f\right) = KE_f$$

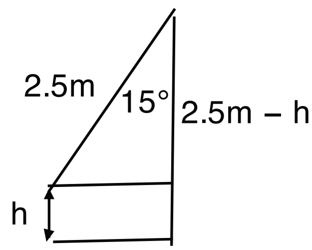
$$m = \frac{KE_f}{\frac{1}{2} v_i^2 + g h_i - g h_f}$$

6.46 (continued)

$$= \frac{293\,\mathrm{J}}{\frac{1}{2}\left(15.7\,\frac{\mathrm{m}}{\mathrm{s}}\right)^2 + \left(9.80\,\frac{\mathrm{m}}{\mathrm{s}^2}\right)(12.7\,\mathrm{m}) - \left(9.80\,\frac{\mathrm{m}}{\mathrm{s}^2}\right)(1.29\,\mathrm{m})}$$

$$= 1.25\,\mathrm{kg}$$ ✓

6.48



Var	Given value	Units	Description
θ	15	°	angle of swing ropes with vertical
L	2.5	m	length of ropes
h		m	height of person from lowest point of swing
PE_{top}		J	potential energy at top of swing
KE_{bot}		J	kinetic energy at bottom of swing
m		kg	mass
g	9.80	$\frac{m}{s^2}$	acceleration due to gravity
v		$\frac{m}{s}$	velocity at bottom of swing

$$\cos\theta = \frac{L - h}{L}$$

$$L\cos\theta = L - h$$

6.48 (continued)

$$h = L - L\cos\theta$$

$$= (2.5\,\text{m}) - (2.5\,\text{m})\cos(15°)$$

$$= 0.0852\,\text{m}$$

$$PE_{\text{top}} = KE_{\text{bot}}$$

$$m\,g\,h = \tfrac{1}{2}\,m\,v^2$$

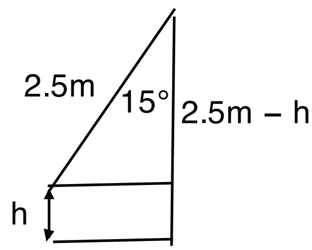
$$g\,h = \tfrac{1}{2}\,v^2$$

$$v = \sqrt{2\,g\,h}$$

$$= \sqrt{2\left(9.80\,\tfrac{\text{m}}{\text{s}^2}\right)(0.0852\,\text{m})}$$

$$= 1.29\,\tfrac{\text{m}}{\text{s}}$$

6.48



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m		kg	mass
g	9.80	$\frac{m}{s^2}$	acceleration due to gravity
v		$\frac{m}{s}$	velocity at bottom of swing

$$\cos\theta = \frac{L - h}{L}$$

$$L\cos\theta = L - h$$

6.48 (continued)

$$h = L - L\cos\theta$$

$$= (2.5\,\mathrm{m}) - (2.5\,\mathrm{m})\cos(15°)$$

$$= 0.0852\,\mathrm{m} \quad ✓$$

$$PE_{\mathrm{top}} = KE_{\mathrm{bot}}$$

$$m\,g\,h = \tfrac{1}{2}\,m\,v^2$$

$$g\,h = \tfrac{1}{2}\,v^2$$

$$v = \sqrt{2\,g\,h}$$

$$= \sqrt{2\left(9.80\,\tfrac{\mathrm{m}}{\mathrm{s}^2}\right)(0.0852\,\mathrm{m})}$$

$$= 1.29\,\tfrac{\mathrm{m}}{\mathrm{s}} \quad ✓$$

6.50

Var	Given value	Units	Description
m		kg	mass of block
g	9.80	$\frac{m}{s^2}$	Acceleration due to gravity
h		m	drop height
$Rtuy$		m	radius of loop
v_B		$\frac{m}{s}$	minimum velocity at top of loop so people don't fall out

$$PE_A = PE_B + KE_B$$

$$m\,g\,h = m\,g\,2\,R + \frac{1}{2}\,m\,v_B^{\ 2}$$

At the top of the loop, there is a normal force and a weight pointing towards the center of the circle. At the very minimum velocity to get around the loop without falling out, the normal force would equal zero. Therefore, the centripetal force would equal the weight.

$$F_c = W$$

$$\frac{m\,v_B^{\ 2}}{R} = m\,g$$

$$\frac{v_B^{\ 2}}{R} = g$$

$$v_B^{\ 2} = g\,R$$

$$v_B = \sqrt{g\,R}$$

6.50 (continued)

Substituting back into the conservation of energy equation for $v_B^{\ 2}$, you get:

$$mgh = mg2R + \frac{1}{2}mgR$$

$$h = 2R + \frac{1}{2}R$$

$$h = 2.5R$$

6.60a

Var	Given value	Units	Description
P_W		W	power in watts
P_{hp}	108	hp	power in horsepower
w	746	W	watts in 1 hp
HP	1	hp	

$$P_W = P_{hp}\left(\frac{w}{HP}\right)$$

$$= (108\,\mathrm{hp})\left(\frac{746\,\mathrm{W}}{1\,\mathrm{hp}}\right)$$

$$= 80568\,\mathrm{W}$$ ✓

Var	Given value	Units	Description
$\#batteries$			number of batteries
P_{BATT}	300.	W	power in one battery

$$\#batteries = \frac{P_W}{P_{BATT}}$$

$$= \frac{80568\,\mathrm{W}}{300.\mathrm{W}}$$

$$= 269.$$ ✓

Parts b) and c) are done the same way.

6.62

Var	Given value	Units	Description
P		W	Average power
W		J	Work
t	3.00	s	time
F	40.0	N	Force
Δx	10.0	m	Distance
θ	0	°	Angle between force and displacement

$$W = F\Delta x\cos\theta$$

$$= (40.0\,\mathrm{N})(10.0\,\mathrm{m})\cos(0°)$$

$$= 400.\,\mathrm{J}$$ ✓

$$P = \frac{W}{t}$$

$$= \frac{400.\,\mathrm{J}}{3.00\,\mathrm{s}}$$

$$= 133.\,\mathrm{W}$$ ✓

6.64

Var	Given value	Units	Description
P		W	power
W		J	Work
t	2.00	s	Duration of work
F		N	Force necessary to lift book
Δx	0.520	m	Distance
θ	0	°	Angle
m	2.25	kg	mass
g	9.80	$\frac{m}{s^2}$	Acceleration due to gravity

$$F = m g$$

$$= (2.25\,\text{kg})\left(9.80\,\frac{\text{m}}{\text{s}^2}\right)$$

$$= 22.0\,\text{N}$$ ✓

$$W = F \Delta x \cos\theta$$

$$= (22.0\,\text{N})(0.520\,\text{m})\cos(0°)$$

$$= 11.4\,\text{J}$$ ✓

6.64 (continued)

$$P = \frac{W}{t}$$

$$= \frac{11.4\,\mathrm{J}}{2.00\,\mathrm{s}}$$

$$= 5.70\,\mathrm{W}$$ ✓

Var	Given value	Units	Description
P_{HP}		hp	power in horsepower
hp	1	hp	
w	746	W	watts in 1 hp

$$P_{\mathrm{HP}} = P\left(\frac{hp}{w}\right)$$

$$= (5.70\,\mathrm{W})\left(\frac{1\,\mathrm{hp}}{746\,\mathrm{W}}\right)$$

$$= 7.64\times10^{-3}\,\mathrm{hp}$$ ✓

6.66

Var	Given value	Units	Description
P_{W}		W	power in watts
P_{hp}	10	hp	power in horsepower
w	746	W	watts in 1 hp
HP	1	hp	
t	18	s	time
W		J	Work
m		kg	mass
g	9.80	$\frac{\mathrm{m}}{\mathrm{s}^2}$	Acceleration due to gravity
Δx	40.	m	Distance
θ	0	°	Angle

$$P_{\mathrm{W}} = P_{\mathrm{hp}}\left(\frac{w}{HP}\right)$$

$$= (10\,\mathrm{hp})\left(\frac{746\,\mathrm{W}}{1\,\mathrm{hp}}\right)$$

$$= 7460\,\mathrm{W} \checkmark$$

$$W = (m\,g)\,\Delta x \cos\theta$$

$$P_{\mathrm{W}} = \frac{W}{t}$$

6.66 (continued)

$$P_W = \frac{m g \Delta x \cos\theta}{t}$$

$$m = \frac{P_W}{g \Delta x \cos\theta} t$$

$$= \frac{7460\,\text{W}}{\left(9.80\,\frac{\text{m}}{\text{s}^2}\right)(40.\,\text{m})\cos(0°)}(18\,\text{s})$$

$$= 340\,\text{kg}$$

6.66

Var	Given value	Units	Description
P_{W}		W	power in watts
P_{hp}	10	hp	power in horsepower
w	746	W	watts in 1 hp
HP	1	hp	
t	18	s	time
W		J	Work
m		kg	mass
g	9.80	$\frac{m}{s^2}$	Acceleration due to gravity
Δx	40.	m	Distance
θ	0	°	Angle

$$P_{W} = P_{hp}\left(\frac{w}{HP}\right)$$

$$= (10\,\text{hp})\left(\frac{746\,\text{W}}{1\,\text{hp}}\right)$$

$$= 7460\,\text{W} \quad ✓$$

$$W = (m\,g)\,\Delta x \cos\theta$$

$$P_{W} = \frac{W}{t}$$

6.66 (continued)

$$P_W = \frac{m g \Delta x \cos\theta}{t}$$

$$m = \frac{P_W}{g \Delta x \cos\theta} t$$

$$= \frac{7460\,\mathrm{W}}{\left(9.80\,\frac{\mathrm{m}}{\mathrm{s}^2}\right)(40.\,\mathrm{m})\cos(0°)}(18\,\mathrm{s})$$

$$= 340\,\mathrm{kg}$$ ✓

6.68

Var	Given value	Units	Description
v_{mph}	50.	$\frac{mi}{h}$	velocity in $\frac{mi}{h}$
v		$\frac{m}{s}$	velocity in $\frac{m}{s}$

$$v = v_{mph} \rightarrow \frac{m}{s}$$

$$= \left(50.\,\frac{mi}{h}\right)\left(1609.3\,\frac{m}{mi}\right)\left(2.777777778\times10^{-4}\,\frac{h}{s}\right)$$

$$= 22.\,\frac{m}{s}$$

Var	Given value	Units	Description
P		W	power in watts
P_{hp}	30.	hp	power in horsepower
hp	1	hp	
w	746	W	watts in 1 horsepower
F		N	retarding force
θ	0	°	angle

$$P = P_{hp}\left(\frac{w}{hp}\right)$$

$$= (30.\,\mathrm{hp})\left(\frac{746\,\mathrm{W}}{1\,\mathrm{hp}}\right)$$

$$= 2.2\times10^{4}\,\mathrm{W}$$

6.68 (continued)

$$P = Fv\cos\theta$$

$$F = \frac{P}{v\cos\theta}$$

$$= \frac{2.2\times10^{4}\ \mathrm{W}}{\left(22.\ \frac{\mathrm{m}}{\mathrm{s}}\right)\cos(0°)}$$

$$= 1000\ \mathrm{N}$$

6.70

Var	Given value	Units	Description
v		$\frac{m}{s}$	velocity of tape in $\frac{m}{s}$
v_{inps}	1.875	$\frac{in}{s}$	velocity of tape in $\frac{in}{s}$
P_{out}		W	power needed to pull tape
F	0.98	N	force
%			
P_{in}	1.8	W	power consumed by motor

$$v = v_{inps} \rightarrow \frac{m}{s}$$

$$= \left(1.875\,\frac{in}{s}\right)\left(0.02540\,\frac{m}{in}\right)$$

$$= 0.04763\,\frac{m}{s}$$

$$P_{out} = F\,v$$

$$= (0.98\,N)\left(0.04763\,\frac{m}{s}\right)$$

$$= 0.047\,W$$

6.70 (continued)

$$\% = \frac{P_{\text{out}}}{P_{\text{in}}} 100$$

$$= \frac{0.047\,\text{W}}{1.8\,\text{W}} 100$$

$$= \boxed{2.6\%}$$

6.72

Var	Given value	Units	Description
v		$\frac{m}{s}$	velocity
v_{kmph}	7.2	$\frac{km}{h}$	velocity
P_L	400	W	power on level treadmill
F		N	force to overcome friction, etc.

$$v = v_{kmph} \rightarrow \frac{m}{s}$$

$$= \left(7.2\,\frac{km}{h}\right)\left(1000\,\frac{m}{km}\right)\left(2.777777778\times10^{-4}\,\frac{h}{s}\right)$$

$$= 2.0\,\frac{m}{s} \quad ✓$$

$$P_L = F\,v$$

$$F = \frac{P_L}{v}$$

$$= \frac{400\,W}{2.0\,\frac{m}{s}}$$

$$= 2.0\times10^{2}\,N \quad ✓$$

6.72 (continued)

Var	Given value	Units	Description
P_G		W	power to overcome gravity
P_I	600	W	power person exerts on inclined treadmill
W_x		N	x–component of weight
m	73	kg	mass of person
g	9.80	$\frac{m}{s^2}$	Acceleration due to gravity
θ		°	angle of incline

$$P_G = P_I - P_L$$

$$= (600\,W) - (400\,W)$$

$$= 200\,W$$

Force to overcome gravity would equal the x–component of their weight.

$$P_G = W_x v$$

$$W_x = \frac{P_G}{v}$$

$$= \frac{200\,W}{2.0\,\frac{m}{s}}$$

6.72 (continued)

$$= 1.0\times10^{2}\ \text{N}$$

$$W_{x} = mg\sin\theta$$

$$\theta = \text{asin}\frac{W_{x}}{mg}$$

$$= \text{asin}\frac{1.0\times10^{2}\ \text{N}}{(73\ \text{kg})\left(9.80\ \frac{\text{m}}{\text{s}^{2}}\right)}$$

$$= 8.0^{\circ}$$