6.20

Var	Given value	Units	Description
KE_a		J	Kinetic energy in part a)
m	1800	kg	Mass
v_a	25	$\frac{m}{s}$	Velocity in part a)

$$KE_a = \frac{1}{2} m v_a^2$$

$$= \frac{1}{2}(1800\,kg)\left(25\,\frac{m}{s}\right)^2$$

$$= 562500\,J$$ ✓

Var	Given value	Units	Description
KE_b		J	Kinetic energy in part b)
v_b	33.3	$\frac{m}{s}$	Velocity in part b)

$$120\,\frac{km}{h}\left(\frac{1000\,m}{1\,km}\right)\left(\frac{1\,h}{3600\,s}\right) = 33.3\,\frac{m}{s}$$

$$KE_b = \frac{1}{2} m v_b^2$$

$$= \frac{1}{2}(1800\,kg)\left(33.3\,\frac{m}{s}\right)^2$$

$$= 9.98\times10^5\,J$$ ✓

6.22

$$25\,g\left(\frac{1\,kg}{1000\,g}\right) = 0.0025\,kg$$

$$90\,\frac{km}{h}\left(\frac{1000\,m}{1\,km}\right)\left(\frac{1\,h}{3600\,s}\right) = 25\,\frac{m}{s}$$

Var	Given value	Units	Description
KE		J	Kinetic energy
m	0.0025	kg	Mass
v	25	$\frac{m}{s}$	Velocity

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

$$= \frac{1}{2}(0.0025\,\text{kg})\left(25\,\frac{\text{m}}{\text{s}}\right)^2$$

$$= 0.78\,\text{J}$$ ✔

6.24

$$2\,\frac{km}{h}\left(\frac{1000\ m}{1\ km}\right)\left(\frac{1\ h}{3600\ s}\right) = 0.55\,\frac{m}{s}$$

Var	Given value	Units	Description
KE_{car}		J	Kinetic energy of car
m_{car}	1000.	kg	Mass of car
v_{car}	0.55	$\frac{m}{s}$	Velocity of car

$$KE_{car} = \frac{1}{2}\,m_{car}\,v_{car}^{2}$$

$$= \frac{1}{2}(1000.\,kg)\left(0.55\,\frac{m}{s}\right)^{2}$$

$$= 1.5\times10^{2}\,J$$ ✓

Var	Given value	Units	Description
KE_{girl}		J	Kinetic energy of girl
m_{girl}	50.	kg	mass of girl
v_{girl}		$\frac{m}{s}$	velocity of girl

$$KE_{girl} = KE_{car}$$

$$= 1.5\times10^{2}\,J$$ ✓

6.24 (continued)

$$KE_{\text{girl}} = \frac{1}{2} m_{\text{girl}} v_{\text{girl}}^{2}$$

$$v_{\text{girl}} = \sqrt{\frac{KE_{\text{girl}}}{\frac{1}{2} m_{\text{girl}}}}$$

$$= \sqrt{\frac{1.5 \times 10^{2}\,\text{J}}{\frac{1}{2}(50.\text{kg})}}$$

$$= 2.4\,\frac{\text{m}}{\text{s}}$$ ✓

6.26

Var	Given value	Units	Description
KE	3.0	J	Kinetic energy
m	1.0	kg	Mass
v_f		$\frac{m}{s}$	final velocity
v_i	0.0	$\frac{m}{s}$	Initial velocity
Δx		m	displacement
t	2.0	s	time

$$KE = \frac{1}{2} m v_f^{\,2}$$

$$v_f = \sqrt{\frac{KE}{\frac{1}{2} m}}$$

$$= \sqrt{\frac{3.0\,\text{J}}{\frac{1}{2}(1.0\,\text{kg})}}$$

$$= 2.4\,\frac{\text{m}}{\text{s}}$$ ✓

6.26 (continued)

$$\Delta x = \tfrac{1}{2}(v_f + v_i)\,t$$

$$= \tfrac{1}{2}\left(\left(2.4\,\tfrac{m}{s}\right) + \left(0.0\,\tfrac{m}{s}\right)\right)(2.0\,s)$$

$$= 2.4\,m$$ ✓

6.28

Var	Given value	Units	Description
F		N	Force of gravity = Centripetal force
G	6.673×10^{-11}	$\frac{m^3}{kg\ s^2}$	Universal gravitational constant
m_1		kg	Mass of satellite
m_2		kg	Mass of planet
r		m	radius of orbit
KE		J	Kinetic energy of satellite
v		$\frac{m}{s}$	Velocity of satellite

find centripetal force on satellite in terms of kinetic energy:

$$KE = \frac{1}{2} m_1 v^2$$

$$2\,KE = m_1 v^2$$

$$F = m_1 \frac{v^2}{r} = \frac{2\,KE}{r}$$

centripetal force on satellite equals gravitational force on satellite by planet

$$\frac{2\,KE}{r} = G \frac{m_1 m_2}{r^2}$$

$$2\,KE = G \frac{m_1 m_2}{r}$$

$$KE\,r = \frac{G m_1 m_2}{2} = constant$$

6.30

When the 6.00 kg block is raised 0.800 m, the 2.00 kg block must be lowered 0.800 m. Find the change in energy of each.

Var	Given value	Units	Description
ΔPE_6		J	change in potential energy of 6 kg block
m_6	6.00	kg	mass of 6 kg block
g	9.80	$\frac{m}{s^2}$	acc. due to grav.
Δh_6	0.800	m	change in height of 6 kg block
ΔPE_2		J	change in potential energy of 6 kg block
m_2	2.00	kg	mass of 6 kg block
Δh_2	–0.800	m	change in height of 2 kg block
ΔPE_{sys}		J	change in potential energy of system

$$\Delta PE_6 = m_6 g \Delta h_6$$

$$= (6.00\,\text{kg})\left(9.80\,\frac{\text{m}}{\text{s}^2}\right)(0.800\,\text{m})$$

$$= 47.0\,\text{J}$$ ✓

6.30 (continued)

$$\Delta PE_2 = m_2 g \Delta h_2$$

$$= (2.00\,\text{kg})\left(9.80\,\frac{\text{m}}{\text{s}^2}\right)(-0.800\,\text{m})$$

$$= -15.7\,\text{J}$$ ✓

$$\Delta PE_{\text{sys}} = \Delta PE_6 + \Delta PE_2$$

$$= (47.0\,\text{J}) + (-15.7\,\text{J})$$

$$= 31.3\,\text{J}$$ ✓

6.32

Var	Given value	Units	Description
PE_{floor}		J	grav. potential energy with respect to floor
m	0.302	kg	Mass
g	9.80	$\frac{m}{s^2}$	Acceleration due to gravity
h_{floor}	0.740	m	Height with respect to floor
$PE_{counter}$		J	grav. potential energy with respect to counter
$h_{counter}$	–0.370	m	difference in position of tabletop and counter

$$PE_{floor} = m\,g\,h_{floor}$$

$$= (0.302\,\text{kg})\left(9.80\,\frac{\text{m}}{\text{s}^2}\right)(0.740\,\text{m})$$

$$= 2.19\,\text{J}$$ ✓

$$0.740\,m - 1.110\,m = -0.370\,m$$

$$PE_{counter} = m\,g\,h_{counter}$$

$$= (0.302\,\text{kg})\left(9.80\,\frac{\text{m}}{\text{s}^2}\right)(-0.370\,\text{m})$$

6.32 (continued)

$$= -1.10\text{J}$$ ✓

6.34

Var	Given value	Units	Description
eff			efficiency
W_{out}		J	work out
W_{in}		J	work in
MA			mechanical advantage
F_{out}		N	force out
F_{in}	12	N	force in
Δx_{in}		m	distance through which crank is turned
$\#rev$	400		revolution through which crank is turned
r	0.30	m	length of crank
Δx_{out}	4.0	m	height load is raised to
m	210.	kg	mass of load
g	9.80	$\frac{m}{s^2}$	acc. due to grav.

$$\Delta x_{in} = (\#rev) 2 \pi r$$

$$= \left((400)\right) 2 \pi (0.30\,m)$$

$$= 754\,m$$ ✓

6.34 (continued)

$$W_{in} = F_{in}\,\Delta x_{in}$$

$$= (12\,\text{N})(754\,\text{m})$$

$$= 9048\,\text{J}$$ ✓

$$F_{out} = m\,g$$

$$= (210.\,\text{kg})\left(9.80\,\frac{\text{m}}{\text{s}^2}\right)$$

$$= 2058\,\text{N}$$ ✓

$$W_{out} = F_{out}\,\Delta x_{out}$$

$$= (2058\,\text{N})(4.0\,\text{m})$$

$$= 8232\,\text{J}$$ ✓

6.34 (continued)

$$eff = \frac{W_{\text{out}}}{W_{\text{in}}}$$

$$= \frac{8232\,\text{J}}{9048\,\text{J}}$$

$$= 0.91$$ ✓

$$MA = \frac{F_{\text{out}}}{F_{\text{in}}}$$

$$= \frac{2058\,\text{N}}{12\,\text{N}}$$

$$= 171.5$$ ✓