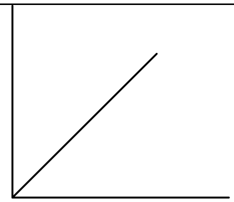
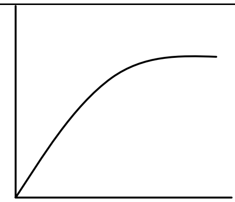
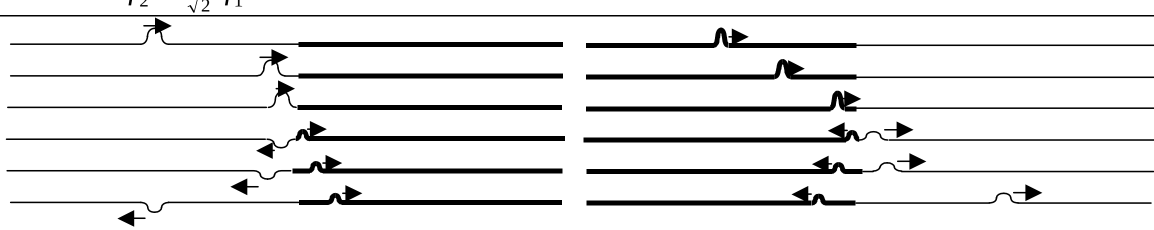
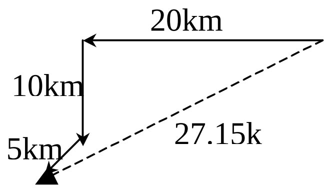
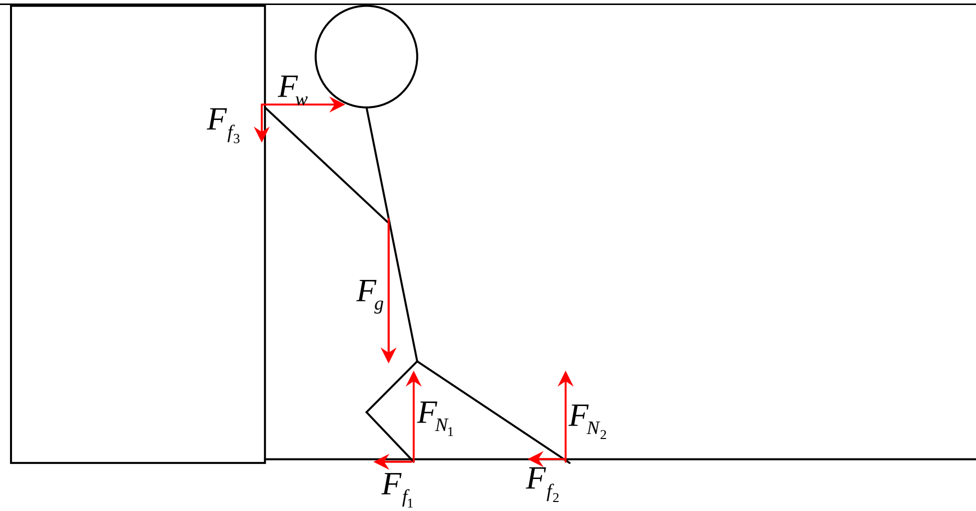
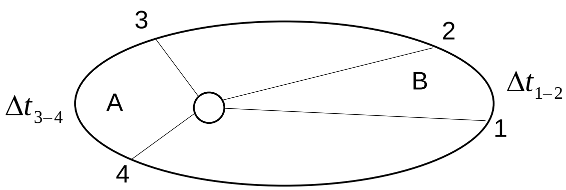
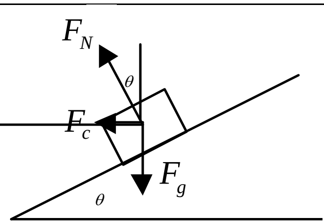
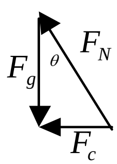
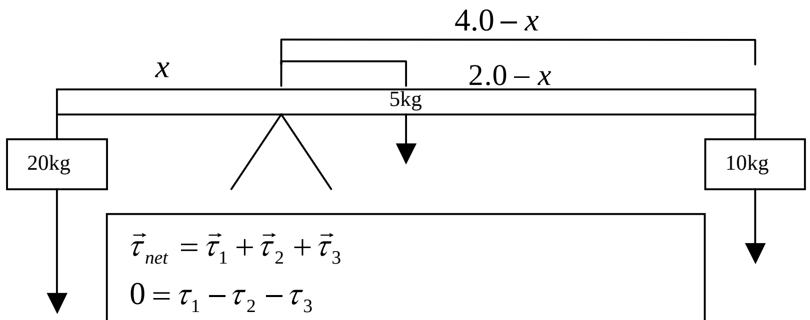
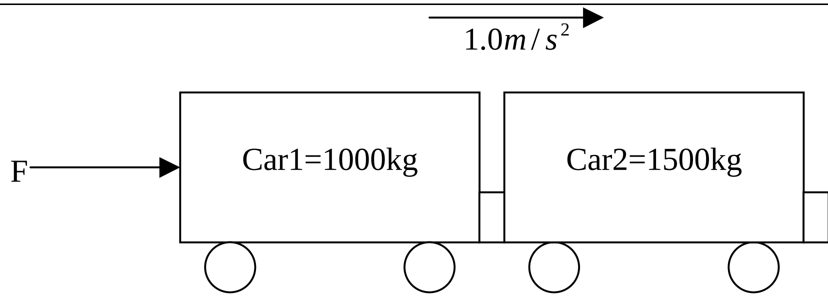
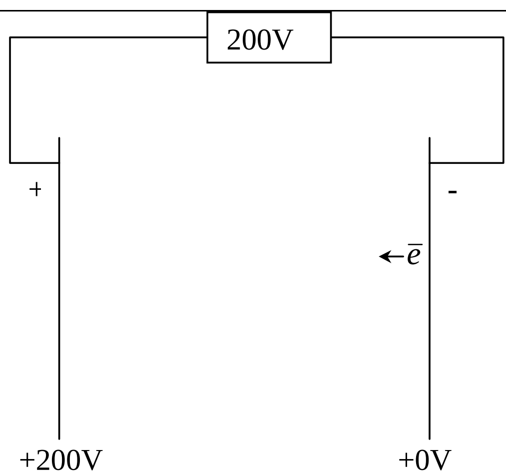
1	a)	b)
		
2	a)	b)
	$m\vec{v}_1 + m\vec{v}_2 = m\vec{v}_1' + m\vec{v}_2'$ $70(2.0) + 0 = (70+5)v_2'$ $140 = (75)v_2'$ $v_2' = 1.87m/s$	*Find E_k of student* $E_k = \frac{1}{2}mv^2$ $= \frac{1}{2}(70)(2)^2$ $= 140J$ *Find E_k of Cart* $E_{k\,cart} = 70\% \times E_{k\,student}$ $\frac{1}{2}mv^2 = 70\% \times 140J$ $\frac{1}{2}(5)v^2 = 98$ $v^2 = 39.2$ $v = 6.26m/s$
3	a) A car driving in a straight line at constant velocity b) A ladder leaning against a wall c) A skydiver falling at terminal velocity	
4	$F_1 = m4\pi^2 Rf_1^{\,2}$ and $F_2 = m4\pi^2 Rf_2^{\,2}$ $F_1 = F_2$ $m4\pi^2 Rf_1^{\,2} = m4\pi^2 2Rf_2^{\,2}$ $f_1^{\,2} = 2f_2^{\,2}$ $f_2^{\,2} = \frac{1}{2}f_1^{\,2}$ $f_2 = \frac{1}{\sqrt{2}}f_1$	
5		

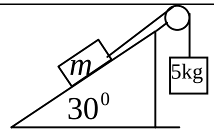
6	
7	
8	An oscillating system where the restoring force is proportional to the displacement from equilibrium. a) Mass oscillating on a spring b) An oscillating pendulum for small amplitudes c) A vibrating guitar string
9	$F_1 = \frac{kq_1q_2}{r^2}$ $F_2 = \frac{k2q_1 2q_2}{(3r)^2}$ $F_2 = \frac{4}{9}\frac{kq_1q_2}{r^2}$ $F_2 = \frac{4}{9}F_1$

10	1) The planets move about the sun in elliptical orbits with the sun at one of the foci. 2) The straight line joining the sun and the planets weeps out equal areas in equal times.  $\Delta t_{1-2} = \Delta t_{3-4}$ *and* $area\ A = area\ B$ 3) The square of the period of revolution of a planet about the sun is proportional to the cube of its mean distance from the sun (true for every planet orbiting the sun) $\frac{R^3}{T^2} = K$, K is the same for earth as it is for Jupiter, Mars, Etc..
11	$v = 72 km/h = 20 m/s$ 200m  $\tan\theta = \frac{F_c}{F_g}$  $\tan\theta = \frac{mv^2/R}{mg}$ $\tan\theta = \frac{v^2}{Rg}$ $\theta = \tan^{-1}\left(\frac{20^2}{200\cdot 9.8}\right)$ $\theta = 11.5^0$

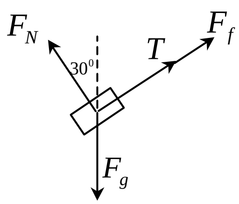
12	 $\vec{\tau}_{net} = \vec{\tau}_1 + \vec{\tau}_2 + \vec{\tau}_3$ $0 = \tau_1 - \tau_2 - \tau_3$ $0 = r_1F_1 - r_2F_2 - r_3F_3$ $0 = r_1m_1g - r_2m_2g - r_3m_3g$ $0 = x(20)g - (2.0 - x)(5.0)g - (4.0 - x)(10)g$ $0 = x(20) - (2.0 - x)(5.0) - (4.0 - x)(10)$ $0 = 20x - 10 + 5.0x - 40 + 10x$ $0 = 35x - 50$ $x = 1.43m$
13	a) A wave is a temporary disturbance in a medium where by energy is transferred from one point in the medium to another without causing the medium to permanently alter is position, shape or composition. b) Frequency is unaffected by a change in the medium c) All waves require a medium with the exception of electromagnetic waves. d) $v = f\lambda$

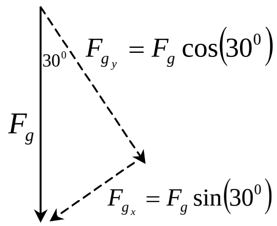
14	 Force required to accelerate Car2 at 1.0m/s[2] $F = ma$ $F = 1500(1.0)$ $F = 1500N$ Therefore $F_{1on2} = 1500N[R]$ and $F_{2on1} = 1500N[L]$
15	$E_{k_1} + E_{g_1} = E_{k_2} + E_{g_2}$ $E_{k_1} + 0 = 0 + E_{g_2}$ $1000J = mgh$ $h = \frac{1000}{20(9.8)}$ $h = 5.1m$
16	 $E_{e_1} + E_{k_1} = E_{e_2} + E_{k_2}$ $qV_1 + \frac{1}{2}mv_1^{\ 2} = qV_1 + \frac{1}{2}mv_2^{\ 2}$ $0 + 0 = (-1.6\times10^{-19})(200) + \frac{1}{2}(9.1\times10^{-31})v_2^{\ 2}$ $\frac{1}{2}(9.1\times10^{-31})v_2^{\ 2} = (1.6\times10^{-19})(200)$ $v_2 = \sqrt{\frac{2(1.6\times10^{-19})(200)}{(9.1\times10^{-31})}}$ $v_2 = 8.39\times10^{6} m/s$

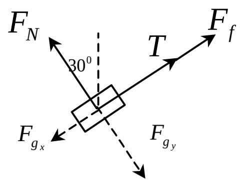
17

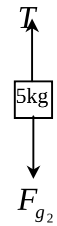


a)









$\vec{F}_{net} = \vec{T} + \vec{F}_{g_2}$

$0 = T - F_{g_2}$

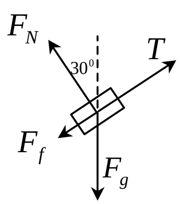
$T = m_2 g$

$T = 5(9.8)$

$T = 49N$

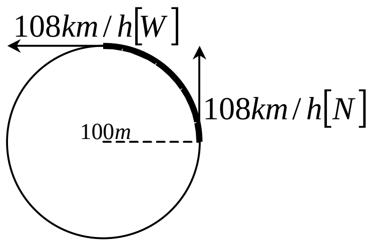
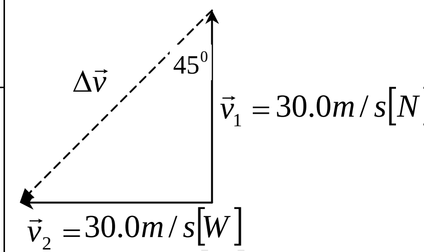
$$\vec{F}_{net} = \vec{F}_f + \vec{T} + \vec{F}_{g_x}$$
$$0 = \mu F_N + T - F_{g_x}$$
$$0 = \mu \left| F_{g_y} \right| + 49 - F_{g_x}$$
$$0 = 0.2m(9.8)\cos(30^0) + 49 - m(9.8)\sin(30^0)$$
$$m = 15.3kg$$

b)



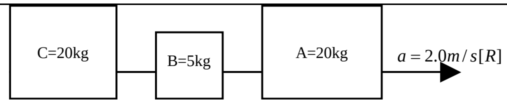
$$\vec{F}_{net} = \vec{F}_f + \vec{T} + \vec{F}_{g_x}$$
$$0 = -\mu F_N + T - F_{g_x}$$
$$0 = -\mu \left| F_{g_y} \right| + 49 - F_{g_x}$$
$$0 = -0.2m(9.8)\cos(30^0) + 49 - m(9.8)\sin(30^0)$$
$$m = 7.4kg$$

18	$R = R_e + Altitude$ $R = 6.38\times10^{6} + 2.0\times10^{7}\,m$ $= 2.638\times10^{7}\,m$ $M_1 = 10000kg$ $M_2 = 5.98\times10^{24}\,kg$ $F_g = \frac{G\,M_1 M_2}{R^2}$ $F_g = 5.73\times10^{3}\,N$ $F_g = \frac{G\,M_1 M_2}{R^2}$ $F_c = \frac{M_1 4\pi^2 R}{T^2}$ $\frac{G\,M_1 M_2}{R^2} = \frac{M_1 4\pi^2 R}{T^2}$ $T = \sqrt{\frac{4\pi^2 R^3}{G\,M_2}}$ $T = 4.26\times10^{4}\,s$ $T = 11.8h$

19	 	$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$ therefore need to find Δt first $\boxed{\Delta t}$ $d = vt$ $t = \frac{d}{v}$ $t = \frac{\frac{1}{4}C}{v}$ $aside\ (108km/h = 30m/s)$ $t = \frac{\frac{1}{4}(2\pi r)}{(30)}$ $t = 5.26s$	 $\boxed{\Delta v}$ $\Delta v = \sqrt{(v_1)^2 + (v_2)^2}$ $= \sqrt{(30)^2 + (30)^2}$ $= 42.4m/s$ $\boxed{\vec{a}}$ $\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$ $a = \frac{42.4}{5.26}$ $a = 8.1m/s^2$ $\vec{a} = 8.1m/s^2[W45^0 S]$
20	a)	b) $d_y = v_{y_1}t + \frac{1}{2}a_y t^2$ $-100 = 0t + \frac{1}{2}(-9.8)t^2$ $t = 4.5s$	c) $d_x = v_x t$ $d_x = 11.6(4.5)$ $d_x = 52m$

	$E_s + E_k = E_s' + E_k'$ $E_s + 0 = 0 + E_k'$ $\frac{1}{2}kx^2 = \frac{1}{2}mv^2$ $v = \sqrt{\frac{kx^2}{m}}$ $v = \sqrt{\frac{(1500)(0.30)^2}{1.0}}$ $v = 11.6m/s$				
21	a) $E_k + E_e = E_k' + E_e'$ $0 + 0 = E_k' + qV$ $0 = E_k' + (-1.6\times10^{-19})(200)$ $E_k' = 3.2\times10^{-17}\,J$	b)i) $\varepsilon = \frac{V}{d}$ $\varepsilon = \frac{200}{0.1}$ $\varepsilon = 2000N/C$ $\vec{\varepsilon} = 2000N/C[R]$	b)ii) $\varepsilon = \frac{F}{q}$ $\varepsilon_{net} = \frac{F_{net}}{q}$ $F_{net} = \varepsilon_{net}q$ $F_{net} = 2000(-1.6\times10^{-19})$ $F_{net} = -3.2\times10^{-16}\,N$ $\vec{F}_{net} = 3.2\times10^{-16}\,N[L]$	b) iii) $\vec{F}_{net} = m\vec{a}$ $3.2\times10^{-16}\,N[L] = (9.11\times10^{-31})(\vec{a})$ $\vec{a} = 3.5\times10^{14}\,m/s^2[L]$	
22	$m = 2000kg$ $\vec{v} = 72km/h[W] = 20m/s$ $\vec{F} = 10000N[E]$ Let E be positive	a) $\vec{F} = m\vec{a}$ $\vec{a} = \frac{\vec{F}}{m}$ $\vec{a} = \frac{10000[E]}{2000}$ $\vec{a} = 5.0m/s[E]$	$\vec{v}_2 = \vec{v}_1 + at$ $v_2 = -20 + (+5.0)(2.0)$ $v_2 = -10m/s$ b) $\vec{v}_2 = 10m/s[W]$	c) $\vec{v}_2 = \vec{v}_1 + at$ $0 = -20 + (+5.0)(t)$ $t = \frac{20}{5.0}$ $t = 4.0s$	d) $\vec{d} = \left(\frac{\vec{v}_1 + \vec{v}_2}{2}\right)t$ $d = \left(\frac{-20+0}{2}\right)(4.0)$ $d = -40m$ $\vec{d} = 40m[W]$

23



a) Find T

$$\vec{F} = m\vec{a}$$
$$F = (20+5+20)(2.0)$$
$$F = 90N$$
$$\vec{F} = 90N[R]$$
$$\therefore T = 90N[R]$$

b) F_{AonB} is the force required to accelerate block B and C

$$\vec{F} = m\vec{a}$$
$$F = (5+20)(2.0)$$
$$F = 50N$$
$$\vec{F} = 50N[R]$$
$$\therefore F_{AonB} = 50N[R]$$

c) Using Newton's 3rd

$$F_{AonB} = -F_{BonA}$$
$$F_{BonA} = 50N[L]$$

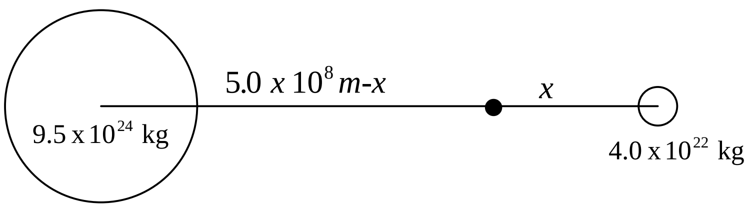
e) F_{BonC} is the force required to accelerate block C

$$\vec{F} = m\vec{a}$$
$$F = (20)(2.0)$$
$$F = 40N$$
$$\vec{F} = 40N[R]$$
$$\therefore F_{BonC} = 40N[R]$$

d) Using Newton's 3rd

$$F_{BonC} = -F_{ConB}$$
$$F_{ConB} = 40N[L]$$

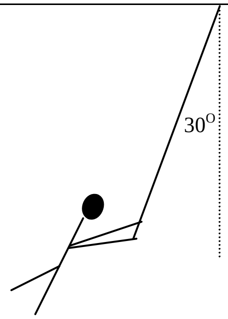
24



$$\vec{F}_{net} = \vec{F}_{g_1} + \vec{F}_{g_2}$$
$$0 = -F_{g_1} + F_{g_2}$$
$$F_{g_1} = F_{g_2}$$
$$\frac{GM_1 m}{R_1^2} = \frac{GM_2 m}{R_2^2}$$
$$\frac{M_1}{R_1^2} = \frac{M_2}{R_2^2}$$
$$M_1 R_2^2 = M_2 R_1^2$$
$$\sqrt{M_1 R_2^2} = \sqrt{M_2 R_1^2}$$

$$\sqrt{M_1} R_2 = \sqrt{M_2} R_1$$
$$\sqrt{M_1} x = \sqrt{M_2}(5.0\times10^8 - x)$$
$$\sqrt{M_1} x + \sqrt{M_2} x = \sqrt{M_2}\, 5.0\times10^8$$
$$x = \frac{\sqrt{M_2}\, 5.0\times10^8}{\left(\sqrt{M_1} + \sqrt{M_2}\right)}$$
$$x = \frac{\sqrt{4.0\times10^{22}}(5.0\times10^8)}{\left(\sqrt{9.5\times10^{24}} + \sqrt{4.0\times10^{22}}\right)}$$
$$x = 3.04\times10^7 m$$

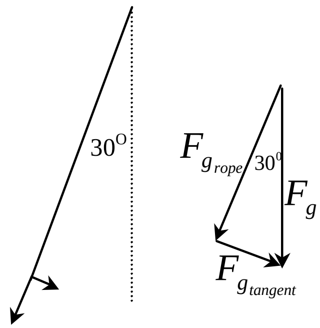
25



a)

$$a_c = \frac{v^2}{R} = \frac{v^2}{R} = \frac{(12)^2}{10} = 14.4 m/s^2$$

b) and d)



b)

$$F_{g_{tan\,gent}} = F_g \sin\theta$$
$$= mg\sin\theta$$
$$= (80)(9.8)\sin(30)$$
$$= 392N$$

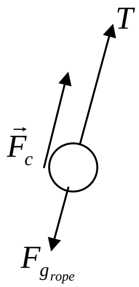
d)

$$F_{g_{rope}} = F_g \cos\theta$$
$$= mg\cos\theta$$
$$= (80)(9.8)\cos(30)$$
$$= 679N$$

c)

$$a_{g_{tan\,gent}} = a_g \sin\theta$$
$$= g\sin\theta$$
$$= (9.8)\sin(30)$$
$$= 4.9 m/s^2$$

d)



$$\vec{F}_c = \vec{T} + \vec{F}_{g_{rope}}$$
$$F_c = T - F_{g_{rope}}$$
$$ma_c = T - mg\cos\theta$$
$$T = ma_c + mg\cos\theta$$
$$T = 80(14.4) + 679$$
$$T = 1831\text{N}$$

26

a)

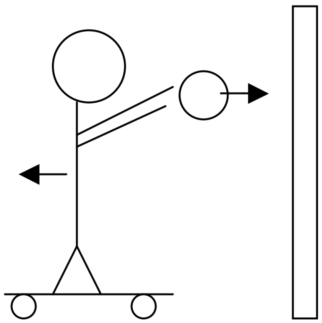
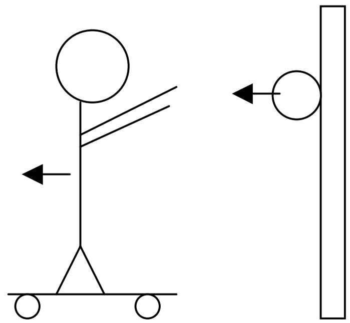
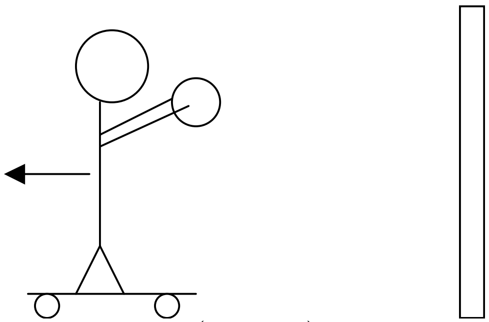
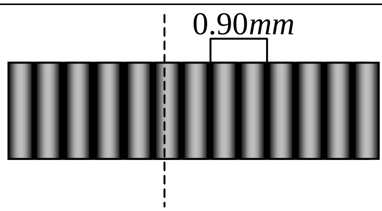
$$E_{k1} + E_{g1} = E_{k2} + E_{g_2}$$
$$E_{k1} + 0 = 0 + E_{g_2}$$
$$\frac{1}{2}mv_1^{\,2} = mgh$$
$$v_1^{\,2} = 2gh$$
$$v_1 = \sqrt{2gh}$$
$$v_1 = \sqrt{2(9.8)(30)}$$
$$v_1 = 24.2 m/s$$

b)

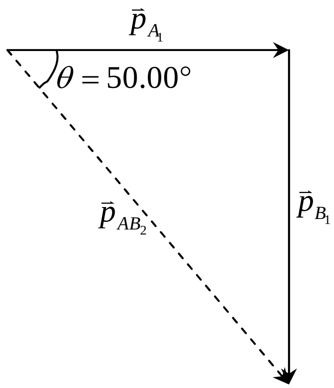
$$E_{k1} + E_{g1} = E_{k3} + E_{g_3}$$
$$E_{k1} + 0 = E_{k3} + E_{g_3}$$
$$\frac{1}{2}mv_1^{\,2} = \frac{1}{2}mv_2^{\,2} + mgh$$
$$\frac{1}{2}mv_2^{\,2} = \frac{1}{2}mv_1^{\,2} - mgh$$
$$v_2^{\,2} = v_1^{\,2} - 2gh$$
$$v_2^{\,2} = (24.2)^2 - 2(9.8)(5)$$
$$v^2{}_2 = 488$$
$$v_2 = 22.1 m/s$$

c)

$$E_{k3} + E_{s3} = E'_{k3} + E'_s$$
$$E_{k3} + 0 = 0 + E'_s$$
$$\frac{1}{2}mv_3^{\,2} = \frac{1}{2}kx^2$$
$$k = \frac{mv_3^{\,2}}{x^2}$$
$$k = \frac{10(22.1)^2}{(0.1)^2}$$
$$k = 488410$$

27	$a)$  Let right be positive $m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$ $0 + 0 = (32)v_1' + (0.5)(5.0)$ $-2.5 = (32)v_1'$ $v_1' = -0.08m/s$	$b)$  since collision is perfectly elastic, ball loses no energy. $v = -5.0m/s$	$c)$  $m_1v_1 + m_2v_2 = (m_1 + m_2)v_2'$ $(32)(-0.08) + (0.5)(-5.0) = (32 + 0.5)v_2'$ $-5.06 = 32.5v_2'$ $v_2' = -0.16m/s$
28	 	a) $2(\Delta x) = 0.90mm$ $\Delta x = 4.5 \times 10^{-4} m$ --- $\Delta x = \frac{\lambda L}{d}$ $\lambda = \frac{\Delta x d}{L}$ $\lambda = \frac{(4.5 \times 10^{-4})(6.0 \times 10^{-4})}{1.0}$ $\lambda = 2.7 \times 10^{-7} m$	b) $\Delta x = \frac{\lambda L}{d}$ $\Delta x = \frac{(2.7 \times 10^{-7})(1.0)}{3.0 \times 10^{-4}}$ $\Delta x = 9.0 \times 10^{-4} m$

<table>
<tr>
<td rowspan="3">29</td>
<td rowspan="3">Given
$m_A = m$
$m_B = m$
$m_{AB} = 2m$
$v_{A_1} = 10.00\, m/s[E]$
$v_{B_1} = ?\ [S]$
$v_{AB_2} = ?\ [E50.00°S]$</td>
<td rowspan="3"><u>Vector Equation</u>
$\vec{p}_{A_1} + \vec{p}_{B_1} = \vec{p}_{AB_2}$

<u>Vector Diagram</u>

</td>
<td>$\vec{p}_{A_1} = m_A \vec{v}_{A_1}$
$= m\vec{v}_{A_1}$
$= m(10.00)$
$= 10.00m$</td>
<td colspan="2">$\vec{p}_{B_1} = m_B \vec{v}_{B_1}$
$= m\vec{v}_{B_1}$</td>
<td>$\vec{p}_{AB_2} = m_{AB} \vec{v}_{AB_2}$
$= 2m\vec{v}_{AB_2}$</td>
</tr>
<tr>
<td colspan="2">Find $\vec{v}_{B_1}$</td>
<td colspan="2">Find $\vec{v}_{AB_2}$</td>
</tr>
<tr>
<td colspan="2">$\tan(\theta) = \frac{\left|\vec{p}_{B_1}\right|}{\left|\vec{p}_{A_1}\right|}$
$\tan(\theta) = \frac{\cancel{m}v_{B_1}}{\cancel{m}v_{A_1}}$
$v_{A_1}\tan(\theta) = v_{B_1}$
$v_{B_1} = 10.00\tan(50.00°)$
$v_{B_1} = 11.92\, m/s$
$\vec{v}_{B_1} = 11.92\, m/s[S]$</td>
<td colspan="2">$\cos(\theta) = \frac{\left|\vec{p}_{A_1}\right|}{\left|\vec{p}_{AB_2}\right|}$
$\cos(\theta) = \frac{\cancel{m}v_{A_1}}{2\cancel{m}v_{AB_2}}$
$v_{AB_2} = \frac{v_{A_1}}{2\cos(\theta)}$
$v_{AB_2} = \frac{10.00}{2\cos(50.00°)}$
$v_{AB_2} = 7.779\, m/s$
$\vec{v}_{AB_2} = 7.779\, m/s[E50.00°S]$</td>
</tr>
</table>