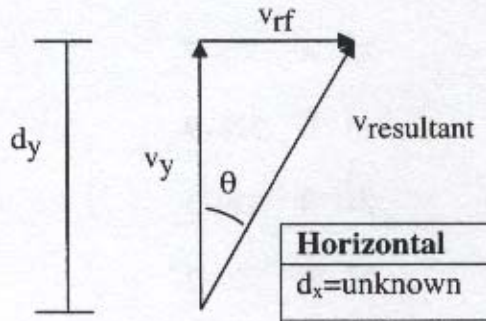
January 2004 Physics 12
Selected Response Questions Answer Key
Total Value 40

		SCO			SCO
1.	**A**	326–3	21.	**B**	328–9
2.	**C**	326–4	22.	**A**	328–7
3.	**B**	325–6	23.	**B**	328–9
4.	**D**	325–6	24.	**B**	329–3
5.	**C**	325–6	25.	**B**	329–2
6.	**D**	325–6	26.	**C**	329–2
7.	**C**	325–6	27.	**C**	329–1
8.	**D**	325–12	28.	**D**	329–1
9.	**B**	325–12	29.	**C**	327–11
10.	**C**	325–13	30.	**C**	327–9
11.	**A**	325–13	31.	**D**	327–9
12.	**B**	327–4	32.	**D**	327–9
13.	**C**	327–4	33.	**A**	327–9
14.	**D**	ACP–2	34.	**B**	329–3
15.	**D**	ACP–2	35.	**B**	329–4
16.	**D**	328–1	36.	**C**	329–4
17.	**A**	328–3	37.	**B**	115–5 fission
18.	**B**	328–6	38.	**D**	329–1
19.	**A**	328–5	39.	**C**	327–9
20.	**D**	ACP–4	40.	**B**	327–9

CONSTRUCTED RESPONSE ANSWER KEY

ALTERNATE SOLUTIONS ARE POSSIBLE AND SHOULD BE SCORED APPROPRIATELY.

41.



Horizontal	Vertical	Angle (θ)
d_x=unknown	d_y=+52 m	Δd_{res}=?
v_x=+3.2 m/s	v_y=+4.0 m/s	v_{res}=unknown
t=unknown	t=unknown	t=unknown

$$\tan\theta = \frac{v_x}{v_y}$$

$$\tan\theta = \frac{3.2\frac{m}{s}}{4.0\frac{m}{s}}$$

$$\tan\theta = 0.80$$

$$\tan^{-1}(0.80) = \theta$$

$$\theta = 39°$$

$$\cos 39° = \frac{d_y}{\Delta d_{res}}$$

$$0.78 = \frac{52\text{ m}}{\Delta d_{res}}$$

$$\Delta d_{res} = \frac{52}{0.78}$$

$$\Delta d_{res} = 67\text{ m}$$

Final Answer: The object's displacement is 67 m [N39° E].

POINT VALUE: 1 point for diagram (vector – either velocity or displacement)
1 point for angle
2 points for getting Δd

42. If Pivot point is at **B**

mass of dump truck (m_T)= 2.00 x 10^4 kg r_T= 16.0 m F_{gT}=1.96 x 10^5 N

mass of bridge (m_b) = 1.25 x 10^5 kg r_b= 12.0 m F_{gb}=1.23 x 10^6 N

Students must demonstrate a knowledge that the sum of the torques about a given pivot point is 0 and that the net force is 0.

$\vec{F}_g = m\vec{g} \quad \tau = Fr$

$\Sigma\tau = 0$

$-1.23\times10^6\text{N}\times12.0\text{ m} - 1.96\times10^5\text{N}\times16.0\text{m} + F_A\times24 = 0$

$\boxed{F_A = 7.43\times10^5\text{N up}}$

$\Sigma\vec{F} = 0$

$\vec{F}_A + \vec{F}_B + \vec{F}_{gT} + \vec{F}_{gb} = 0$

$+7.43\times10^5\text{N} + F_B - 1.96\times10^5\text{N} - 1.225\times10^6\text{N} = 0$

$\boxed{F_B = 6.78\times10^5\text{N up}}$

FINAL ANSWER: Pillar A supports 7.43 x 10^5 N and Pillar B supports 6.78 x 10^5 N.

POINT VALUE: 2 points for torque calculation
1 point for F_A
1 point for F_B

43. Given: m_1 is 4.0 kg $\vec{a} = 2.0\ \text{m/s}^2$

$$\vec{F}_{NET} = m\vec{a}$$
$$F_{g2} - F_{g1} = (m_2 + m_1)a$$
$$m_2 g - m_1 g = m_1 a + m_2 a$$
$$m_2 g - m_2 a = m_1 a + m_1 g$$
$$m_2 = \frac{m_1(a+g)}{g-a} = \frac{4.0\text{kg}(2.0\text{m/s}^2 + 9.8\text{m/s}^2)}{(9.8\text{m/s}^2 - 2.0\text{m/s}^2)} = 6.1\text{kg}$$

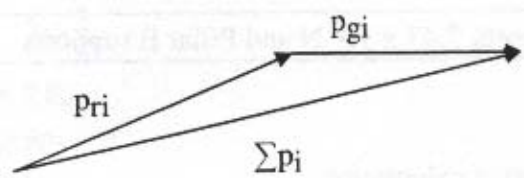
$$\vec{F} = m\vec{a}$$
$$F_T - F_{g1} = m_1 a$$
$$F_T = m_1 a + m_1 g = m_1(a+g) = (4.0kg)(2.0\text{m/s}^2 + 9.8\text{m/s}^2)$$
$$F_T = 47\text{N}$$

FINAL ANSWER: The mass on the right is 6.1 kg, and the tension is 47 N.

POINT VALUE: 3 points for mass and 2 points for tension

44. Mass of green car (m_g) = 1.00 x 10^3 kg
Initial v of green car (v_{gi}) = 30 m/s [E]

Mass of red car (m_r) = 1.50 x 10^3 kg
Initial v of red car (v_{ri}) 25 m/s [E 37.0° N]



Students need to show solving of components if they are using component method.

$\vec{v}_{rix} = v_{ri}\cos\theta$ $\quad \vec{v}_{riy} = v_{ri}\sin\theta$ $\quad \vec{v}_{gfx} = v_{gf}\cos\theta$ $\quad \vec{v}_{gfy} = v_{gf}\sin\theta$

$\vec{v}_{rix} = 25\cos37$ $\quad \vec{v}_{riy} = 25\sin37$ $\quad \vec{v}_{gfx} = 24.1\cos32.6$ $\quad \vec{v}_{gfy} = 24.1\sin32.6$

$v_{rix} = +20.0$ m/s $\quad v_{riy} = +15.0$ m/s $\quad v_{gfx} = +20.3$ m/s $\quad v_{gfy} = +13.0$ m/s

BEFORE		AFTER	
$m_g = 1.00 \times 10^3$ kg	$m_r = 1.50 \times 10^3$ kg	$m_g = 1.00 \times 10^3$ kg	$m_r = 1.50 \times 10^3$ kg
V_{gix}=+30.0m/s	V_{rix}=+20.0m/s	V_{gfx}=+20.3 m/s	V_{rfx}=? m/s
V_{giy}= 0 m/s	V_{riy}=+15.0m/s	V_{gfy}= +13.0 m/s	V_{rfy}=? m/s

$$\Sigma\vec{p}_{ix} = \Sigma\vec{p}_{fx}$$

$$m_g\vec{v}_{gix} + m_r\vec{v}_{rix} = m_g\vec{v}_{gfx} + m_r\vec{v}_{rfx}$$

$$1.00\times10^3\,\text{kg}\times(+30\frac{\text{m}}{\text{s}}) + 1.50\times10^3\,\text{kg}\times(+20\frac{\text{m}}{\text{s}}) = 1.00\times10^3\,\text{kg}\times(+20.3\frac{\text{m}}{\text{s}}) + 1.50\times10^3\,\text{kg}\times\vec{v}_{rfx}$$

$$+6.00\times10^4\,kg\frac{\text{m}}{\text{s}} = +2.03\times10^4\,kg\frac{\text{m}}{\text{s}} + 1.50\times10^3\,kg\times\vec{v}_{rfx}$$

$$+3.97\times10^4\,kg\frac{\text{m}}{\text{s}} = 1.50\times10^3\,kg\times\vec{v}_{rfx}$$

$$v_{rfx} = +26.5\frac{m}{s}$$

$$\Sigma\vec{p}_{iy} = \Sigma\vec{p}_{fy}$$

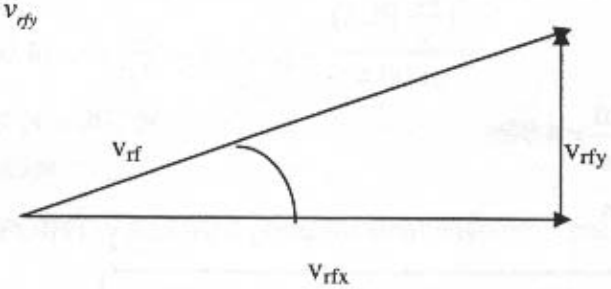
$$m_g\vec{v}_{giy} + m_r\vec{v}_{riy} = m_g\vec{v}_{gfy} + m_r\vec{v}_{rfy}$$

$$1.00\times10^3\,\text{kg}\times(0\frac{\text{m}}{\text{s}}) + 1.50\times10^3\,\text{kg}\times(+15\frac{\text{m}}{\text{s}}) = 1.00\times10^3\,\text{kg}\times(+13.0\frac{\text{m}}{\text{s}}) + 1.50\times10^3\,\text{kg}\times\vec{v}_{rfy}$$

$$+2.25\times10^4\,\text{kg}\frac{\text{m}}{\text{s}} = +1.3\times10^4\,\text{kg}\frac{\text{m}}{\text{s}} + 1.50\times10^3\,\text{kg}\times\vec{v}_{rfy}$$

$$+9.50\times10^3\,\text{kg}\frac{\text{m}}{\text{s}} = 1.50\times10^3\,\text{kg}\times\vec{v}_{rfy}$$

$$v_{rfy} = +6.33\frac{\text{m}}{\text{s}}$$



$$\vec{v}_{rf}^2 = \vec{v}_{rfy}^2 + \vec{v}_{rfx}^2 \qquad \tan\theta = \frac{v_{rfy}}{v_{rfy}}$$

$$\vec{v}_{rf}^2 = (+6.33\frac{\text{m}}{\text{s}})^2 + (+26.5\frac{\text{m}}{\text{s}})^2 \qquad \tan\theta = \frac{+6.33\frac{\text{m}}{\text{s}}}{+26.5\frac{\text{m}}{\text{s}}}$$

$$\vec{v}_{rf}^2 = 742\frac{\text{m}^2}{\text{s}^2} \qquad \tan^{-1}0.239 = \theta$$

$$\vec{v}_{rf} = 27.2\frac{\text{m}}{\text{s}} \qquad \theta = 13.4°$$

The final velocity of the red car is 27.2 m/s [E13.4° N].

POINT VALUES: 1 point for diagram, 2 points for magnitude and direction of final answer, 5 points for method

45. Students need to break the initial velocity into components.

Horizontal	Vertical
$v_x = +30.6$ m/s	$v_{iy} = +25.7$ m/s
$d_x = ?$	$\Delta d_y = +6.30$ m
	$a_y = -9.8$ m/s^2
	t=?

$$\vec{v}_{ix} = \vec{v}_i \cos\theta \qquad \vec{v}_{iy} = \vec{v}_i \sin\theta$$

$$\vec{v}_{ix} = 40\frac{\text{m}}{\text{s}}\cos 40 \qquad \vec{v}_{iy} = 40\frac{\text{m}}{\text{s}}\sin 40$$

$$\vec{v}_{ix} = +30.6\frac{\text{m}}{\text{s}} \qquad \vec{v}_{iy} = +25.7\frac{\text{m}}{\text{s}}$$

$$\Delta\vec{d}_y = \vec{v}_{iy}\Delta t + \frac{1}{2}\vec{a}_y\Delta t^2$$

$$+6.30\text{ m} = +25.7\frac{\text{m}}{\text{s}}\Delta t + \frac{1}{2}(-9.8\frac{\text{m}}{\text{s}^2})\Delta t^2$$

This can be put into the quadratic formula to get

Δt=0.258 s or 4.99 s

Then:

note: solving for v_{fy} and then *t* is acceptable

$$\vec{d}_x = \vec{v}_x\Delta t$$

$$\vec{d}_x = +30.6\frac{\text{m}}{\text{s}} \times 4.99\text{s}$$

$$\vec{d}_x = +153\text{ m}$$

The horizontal distance the ball travels is 153 m.

POINT VALUES: 1 point for components, 1 point for answer, remaining 3 points for method.

46.a)

POINT VALUE: 1 point

b)

GIVEN:
v = 3.20 m/s
m= 80.0 kg
r = 4.00m

$$\vec{F}_c = m\vec{a}_c$$

$$\vec{F}_T + \vec{F}_g = m\vec{a}_c$$

$$F_T - mg = 80.0\ \text{kg} \times \frac{v^2}{r}$$

$$F_T - 80.0\ \text{kg}(9.8\ \frac{\text{m}}{\text{s}^s}) = 80.0\ \text{kg} \times \frac{(3.20\ \frac{\text{m}}{\text{s}})^2}{4.00\ \text{m}}$$

$$F_T - 784\ \text{N} = 205\ \text{N}$$

$$F_T = +989\text{N}$$

The tension will be 989 N

POINT VALUE: 1 point for final answer, 2 points for method

c)

$F_T = 1800.\ \text{N}$

$v_{min} = ?$

$\vec{F}_c = \vec{F}_T + \vec{F}_g$

$F_c = 1800\ \text{N} - mg \qquad F_c = 1800\ \text{N} - 784\ \text{N}$

$\frac{mv^2}{r} = 1016\ \text{N} \qquad v^2 = \frac{(1016\text{N})(r)}{m}$

$v^2 = 51.0\frac{\text{m}^2}{\text{s}^2}$

$v = 7.13\ \frac{\text{m}}{\text{s}}$

The minimum speed will be 7.13 m/s

POINT VALUE: 1 point for final answer
1 point for method

47.
GIVEN:
m_1=40.0 kg
m_2= 40.0 kg
r= 8.00 m
G= 6.67 X 10^{-11} Nm^2/kg^2

$$F_g = \frac{Gm_1m_2}{r^2}$$

$$F_g = \frac{6.67 \times 10^{-11} \frac{Nm^2}{kg^2}(40.0kg)(40.0kg)}{(8.00\ m)^2}$$

$$F_g = 1.67 \times 10^{-9}\ N$$

The gravitational force of attraction is 1.67 X 10^{-9} N.

POINT VALUE: answer 1, method 1

b)

$$F_g \alpha \frac{m_1}{r^2}$$

$$F_g \alpha \frac{2m_1}{r^2}$$ We do not want to have a change in F_g

so therefore we need to figure out how to get a 2 on the bottom of the expression.

$$F_g \alpha \frac{2m_1}{2r^2}$$

$$F_g \alpha \frac{2m_1}{(\sqrt{2}r)^2}$$

$\sqrt{2} \times r$ = new r

$1.41 \times 8.00\ m = 11.3\ m$

The new radius would have to be 11.3 m

POINT VALUE: answer 1, method 1.

c) i) The strength of the gravitational field diminishes with the square of the separation, but is still significant at this distance. POINT VALUE: 1

ii) This answer should include an understanding that there is an absence of an interaction force when one "feels" weightless. POINT VALUE: 1

48.

GIVEN: $T_1 = 0.12$ s

$$\frac{T_2}{T_1} = \frac{2\pi\sqrt{\frac{m_2}{k}}}{2\pi\sqrt{\frac{m_1}{k}}} = \frac{\sqrt{m_2}}{\sqrt{m_1}} = \frac{\sqrt{3}}{\sqrt{1}} = \frac{\sqrt{3}}{1}$$

$$T_2 = \sqrt{3}(T_1) = \sqrt{3} \times 0.12\text{s} = 0.21\text{s}$$

$\boxed{\text{The period for the heavier mass is 0.21 s.}}$ POINT VALUE: answer 1, method 1

49. A) The positive peak is induced by the North pole and the negative peak is induced by the South pole.

POINT VALUE: 1

B) The South pole of the magnet goes through the coil after the North pole, and will be going faster due to gravitational acceleration. The higher speed creates a higher potential.

POINT VALUE: 2

C) The sketch should show a negative peak first, followed by a slightly higher positive peak.

POINT VALUE: 2

50. GIVEN:

$Q_A = +45\ \mu C$

$Q_B = +36\ \mu C$

$Q_C = -55\ \mu C$

$r_{AB} = 0.0320$ m

$r_{BC} = 0.0470$ m

$k = 9.0 \times 10^9\ Nm^2/kg^2$

$$F_{BC} = \frac{kQ_BQ_C}{r^2}$$

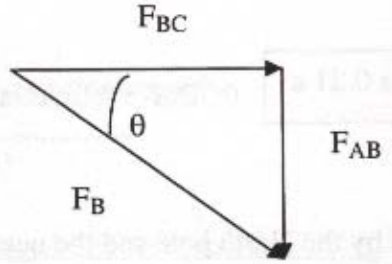
$$F_{BC} = \frac{9.0 \times 10^9 \frac{Nm^2}{kg^2}(36.0 \times 10^{-6}C)(55.0 \times 10^{-6}C)}{(0.0470\ m)^2}$$

$$F_{BC} = 8.07 \times 10^3\ N \rightarrow$$

$$F_{AB} = \frac{kQ_A Q_B}{r^2}$$

$$F_{AB} = \frac{9.0 \times 10^9 \frac{Nm^2}{kg^2}(45.0 \times 10^{-6} C)(36.0 \times 10^{-6} C)}{(0.0320\ m)^2}$$

$$F_{AB} = 1.42 \times 10^4\ N \downarrow$$



$$F_B^2 = F_{BC}^2 + F_{AB}^2$$

$$F_B^2 = (8.07 \times 10^3 N)^2 + (1.42 \times 10^4 N)^2$$

$$F_B = 1.63 \times 10^4\ N$$

$$\tan\theta = \frac{F_{AB}}{F_{BC}}$$

$$\tan\theta = \frac{1.42 \times 10^4 N}{8.07 \times 10^3 N}$$

$$\tan^{-1}(1.76) = \theta$$

$$\theta = 60.4°$$

The net force acting on charge B is 1.63 X 10^4 N [E 60.4°S].

POINT VALUE: diagram 1 point
each force 1 point
magnitude and direction of final answer 2 points

CASE STUDY ANSWER KEY

51.

A) fuel, moderator, and coolant

POINT VALUE: 1 pt (all or nothing)

B)

$^{238}_{92}U + ^{1}_{0}n \rightarrow ^{239}_{92}U$

$^{239}_{92}U \rightarrow ^{239}_{93}Np + ^{0}_{-1}e$

$^{239}_{93}Np \rightarrow ^{239}_{94}Pu + ^{0}_{-1}e$

$^{239}_{94}Pu \rightarrow ^{235}_{92}U + ^{4}_{2}He$

(neutron, beta, beta, alpha particle)

POINT VALUE: 2 points (0.5 points each), alternate expressions for beta and alpha accepted)

C)

i) approximately 0.7 for Uranium – 235
approximately 4.5 for Uranium – 238

POINT VALUE: 1 pt (0.5 for each)

ii)

The half-life of Uranium-235 is shorter than that of U-238.
The relative concentration of U-235 to U-238 decreased to the point that the nuclear reaction could no longer be sustained.

Students should connect the knowledge that half-lives of the elements are different (based on the graphs), which will change the relative concentration of the Uranium isotopes.

POINT VALUE: 1 point
0.5 if they state half-life as the cause
0.5 if they state how the ratio affects the chain reaction

D) Control Rods act as neutron absorbers POINT VALUE: 1 point

E)

$$^{235}_{92}U + ^{1}_{0}n \rightarrow 3\,^{1}_{0}n + ^{141}_{56}Ba + ^{92}_{36}Kr$$

235.044 u+1.009 u $\rightarrow$ 3(1.009 u) + 140.883 u + 91.905 u

236.053 u $\rightarrow$ 235.815 u

mass defect = 236.053 u-235.815 u

mass defect = 0.238 u

$$0.238\text{ u} \times 1.6605 \times 10^{-27}\,\frac{\text{kg}}{\text{u}} = 3.95\times10^{-28}\text{kg}$$

$$E = mc^2$$

$$E = 3.95\times10^{-28}\text{kg}\times(3.00\times10^{8}\,\frac{\text{m}}{\text{s}})^2$$

$$E = 3.56\times10^{-11}\,\frac{\text{J}}{\text{atom}}$$

The amount of energy, in Joules per atom is 3.56×10^{-11}.

POINT VALUE: 4 points The following breakdown is for the method shown above.
2 points for mass defect
2 points for energy per atom