BLM 10-4: Chapter 10 Test/Assessment

Answers

1. **(a)** first

(b) second

(c) equal force

(d) the sum of each of the components of all forces is zero and the sum of the torques acting on the object is zero

(e) $\text{N} \cdot \text{s}$

(f) external

(g) mass

(h) isolated

(i) kinetic energy

2. Upward

3.

$$F_{\text{T}} = F_{\text{g}}$$
$$F_{\text{T}} = mg$$
$$F_{\text{T}} = (4.2 \text{ kg})\left(9.81 \ \frac{\text{m}}{\text{s}^2}\right)$$
$$F_{\text{T}} \cong 41 \text{ N}$$

4.

$$F_f = \mu F_N$$
$$\left|\vec{F}_{app}\right| = \left|\vec{F}_f\right|$$
$$\left|\vec{F}_{app}\right| = \mu mg$$
$$\left|\vec{F}_{app}\right| = 0.21(78\ \text{kg})\left(9.81\frac{\text{m}}{\text{s}^2}\right)$$
$$\left|\vec{F}_{app}\right| \cong 1.6\times10^2\ \text{N}$$

5.

$$F_f = \mu F_N$$
$$F_f = \mu mg$$
$$\mu = \frac{F_f}{mg}$$
$$\mu = \frac{75\ \text{N}}{(65\ \text{kg})\left(9.81\ \frac{\text{m}}{\text{s}^2}\right)}$$
$$\mu \cong 0.12$$

6. As the elevator slows to a stop, your acceleration is downward, so the net force on you is downward: $\vec{F}_{net} = m\vec{a}$. Since $\vec{a}$ is negative, $\vec{F}_{net}$ is negative or downward. The net force on you is the sum of the gravitational force acting downward and the normal force of the elevator acting upward: $\vec{F}_{net} = -\vec{F}_g + \vec{F}_N < 0$; therefore, $\vec{F}_N < \vec{F}_g$. Therefore the normal force is less than the gravitational force.

7. The force exerted by your arm muscles and the force exerted by the rope

8.

$$\vec{F}_{net}(\text{on elevator}) = m\vec{a}$$
$$\vec{F}_{cable} + \vec{F}_g = m\vec{a}$$
$$\vec{F}_{cable} + m\vec{g} = m\vec{a}$$
$$\vec{F}_{cable} = m\vec{a} - m\vec{g}$$
$$\vec{F}_{cable} = \left(1.10\times10^3\ \text{kg}\right)\left[+0.45\ \frac{\text{m}}{\text{s}^2} - \left(-9.81\ \frac{\text{m}}{\text{s}^2}\right)\right]$$
$$\vec{F}_{cable} = 1.1\times10^4\ \text{N}[\text{upward}]$$

Since the cable is exerting an upward force on the elevator, the elevator is exerting a downward force of 1.1×10^4 N on the cable.

9. (a)

$$F_g = m_{box}g \qquad F_g = m_{weight}g$$
$$m_{box} = \frac{F_g}{g} \qquad m_{weight} = \frac{F_g}{g}$$
$$m_{box} = \frac{47\ \text{N}}{9.81\ \frac{\text{m}}{\text{s}^2}} \qquad m_{weight} = \frac{25\ \text{N}}{9.81\ \frac{\text{m}}{\text{s}^2}}$$
$$m_{box} = 4.791\ \text{kg} \qquad m_{weight} = 2.5484\ \text{kg}$$
$$\vec{F} = m\vec{a}$$
$$\vec{a} = \frac{\vec{F}}{m}$$
$$\vec{a} = \frac{25\ \text{N}[\text{forward}]}{4.791\ \text{kg} + 2.5484\ \text{kg}}$$
$$\vec{a} \cong 3.4\ \frac{\text{m}}{\text{s}^2}[\text{forward}]$$

(b) The force that the weight exerts on the cord accelerates the box, so

$$\vec{F}_T = m_{box}\vec{a}$$
$$\vec{F}_T = (4.8\ \text{kg})\left(3.4\ \frac{\text{m}}{\text{s}^2}\right)$$
$$\vec{F}_T = 16\ \text{N}[\text{toward weight}]$$

10. The 20 kg child must sit 3.1 m to the right of the pivot point to balance the seesaw.

Use second condition for static equilibrium.

$$\sum \tau = 0$$

Choose axis of rotation to be pivot point so only force of gravity acting on each child will be only forces affecting net torque. Distances to the left of pivot point are negative and distances to the right of pivot point are positive. Let 25 kg child sit to the left of pivot point.

$$m_1 g\vec{r}_1 + m_2 g\vec{r}_2 = 0$$
$$\vec{r}_2 = -\left(\frac{m_1}{m_2}\right)\vec{r}_1$$

$$\vec{r}_2 = -\left(\frac{25\ \text{kg}}{20\ \text{kg}}\right)(-2.5\ \text{m})$$

$$\vec{r}_2 = 3.1\ \text{m [to the right]}$$

11. (a) The biceps muscle must exert a force of 4.4×10^2 N.

Use second condition for static equilibrium.

$$\sum \tau = 0$$

Choose axis of rotation to be elbow. Choose coordinate system where up and to the right are positive. Let m_1 be mass in hand and m_2 be mass of forearm and hand, and r_1 and r_2 are the corresponding lever arms. Let force exerted by biceps muscle be F and corresponding lever arm r_3. In order to lift object, F must be pointing up while the force of gravity on the object and forearm-hand system is pointing down.

$$-m_1gr_1 - m_2gr_2 + Fr_3 = 0$$

$$F = \frac{g}{r_3}(m_1r_1 + m_2r_2)$$

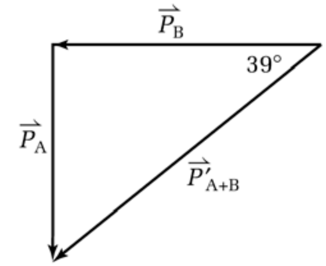
$$F = \left(\frac{9.81\ \frac{\text{m}}{\text{s}^2}}{0.050\ \text{m}}\right)\left[(5.5\ \text{kg})(0.35\ \text{m}) + (2.0\ \text{kg})(0.15\ \text{m})\right]$$

$$F = 4.4 \times 10^2\ \text{N}$$

(b) The biceps muscle must exert a force of 4.4×10^2 N.

This part is solved in exactly the same way as part (a) except that the perpendicular distance (x-component) for the lever arm must be evaluated. The angle between the forearm and upper arm is 120° which means that the x-component of each lever arm in the net torque equation must be multiplied by cos 30°. This factor can be cancelled out, leaving the magnitude of the force unchanged.

12. The vector sum of the momentum of the cars before the collision is equal to the momentum of the wreck after the collision. Car B was travelling at 28 m/s[W] before the collision. See the following diagram and calculations.



$$\vec{p}_A + \vec{p}_B = \vec{p}'_{A+B}$$

$$\tan 39^\circ = \left|\frac{\vec{p}_A}{\vec{p}_B}\right|$$

$$\tan 39^\circ = \frac{m_A|\vec{v}_A|}{m_B|\vec{v}_B|}$$

$$(m_B|\vec{v}_B|)\tan 39^\circ = m_A|\vec{v}_A|$$

$$|\vec{v}_B| = \frac{m_A\vec{v}_A}{\tan 39^\circ\, m_B}$$

$$|\vec{v}_B| = \frac{(1200\ \text{kg})(17\ \frac{\text{m}}{\text{s}})}{(0.8098)(900\ \text{kg})}$$

$$|\vec{v}_B| = 28\ \frac{\text{m}}{\text{s}}$$

BLM 11-3: Chapter 11 Test/Assessment Answers

1. (d) **2.** (c) **3.** (c) **4.** (c) **5.** (c)

6. The velocity and the acceleration of the two riders are the same. The static friction force required to hold the more massive person in place is greater than that required to hold the other person.

7. The soccer ball is in the air for 3.59 s.

$$T = \frac{2v_i \sin\theta}{g}$$

$$T = \frac{2\left(30.0\,\frac{\text{m}}{\text{s}}\right)\sin 36.0^\circ}{9.81\,\frac{\text{m}}{\text{s}^2}}$$

$$T \cong 3.59\ \text{s}$$

8. The horizontal distance travelled by the soccer ball is 87.3 m.

$$R = \frac{v_i^2 \sin 2\theta}{g}$$

$$R = \frac{\left(30.0\,\frac{\text{m}}{\text{s}}\right)^2 \sin 2\left(36.0^\circ\right)}{9.81\,\frac{\text{m}}{\text{s}^2}}$$

$$R \cong 87.3\ \text{m}$$

9. The maximum height achieved by the soccer ball is 15.8 m.

$$H = \frac{v_i^2 \sin^2\theta}{2g}$$

$$H = \frac{\left(30.0\,\frac{\text{m}}{\text{s}}\right)^2 \sin^2 36.0^\circ}{2\left(9.81\,\frac{\text{m}}{\text{s}^2}\right)}$$

$$H = 15.8\ \text{m}$$

10. The runner's centripetal acceleration is 0.48 m/s^2.

$$a_c = \frac{v^2}{r}$$

$$a_c = \frac{\left(5.6\,\frac{\text{m}}{\text{s}}\right)^2}{65\ \text{m}}$$

$$a_c \cong 0.48\ \frac{\text{m}}{\text{s}^2}$$

11. The velocity of the coin as it rolled across the desk was 0.48 m/s.

$$\Delta d_y = v_{iy}\Delta t + \tfrac{1}{2}a\Delta t^2$$

$$\Delta d_y = 0 + \tfrac{1}{2}a\Delta t^2$$

$$\Delta t = \sqrt{\frac{2\Delta d_y}{a}}$$

$$\Delta t = \sqrt{\frac{2(-1.33\ \text{m})}{\left(-9.81\,\frac{\text{m}}{\text{s}^2}\right)}}$$

$$\Delta t \cong 0.52\ \text{s}$$

$$v_x = \frac{\Delta d_x}{\Delta t}$$

$$v_x = \frac{0.25\ \text{m}}{0.5207\ \text{s}}$$

$$v_x \cong 0.48\ \frac{\text{m}}{\text{s}}$$

12. **(a)** The force exerted by the wire on the object is 2.7 N.

$$F_c = m\frac{v^2}{r}$$

$$F_c = m\frac{\left(\frac{\Delta d}{\Delta t}\right)^2}{r}$$

$$F_c = m\frac{\left(\frac{2\pi r}{T}\right)^2}{r}$$

$$F_c = m4\pi^2 rf^2$$

$$F_c = (0.050\ \text{kg})4\pi^2(0.150\ \text{m})\left(3.0\ \text{s}^{-1}\right)^2$$

$$F_c \cong 2.7\ \text{N}$$

(b) The speed of the disk is 2.8 m/s.

$$v = \frac{\Delta d}{\Delta t}$$

$$v = \frac{2\pi r}{T}$$

$$v = 2\pi rf$$

$$v = 2\pi(0.150\ \text{m})\left(3.00\ \text{s}^{-1}\right)$$

$$v \cong 2.8\ \frac{\text{m}}{\text{s}}$$

BLM 12-5: Chapter 12 Test/Assessment

Answers

1. (a) **2.** (b) **3.** (b) **4.** (a) **5.** (b) **6.** (b)

7. Brahe believed in an Earth-centred universe in which all planets other than Earth orbited the Sun. In formulating his laws of planetary motion, Kepler applied Brahe's data to the motions of planets in a Sun-centred system.

8. During the period between July and December, Earth is moving closer to the Sun, and as any planet moves closer to the Sun, its orbital speed increases.

9. **(a)** If the mass of one object doubled, the gravitational force between the two bodies would be doubled.

(b) If the distance between two bodies was doubled, the gravitational force between them would be one fourth as great.

10. To find a planet's period using Kepler's third law, you need to know the period of another planet and the orbital radii of both planets.

11. The surface gravity of each planet varies inversely with the square of the radius of the planet. Jupiter's radius is much greater (almost 11 times) than Earth's radius.

12. The satellite moves with uniform circular motion, so the curvature of Earth's surface exactly matches the curvature of the trajectory of the satellite. Earth's surface "falls away" from the satellite at the same rate that the satellite falls toward Earth.

13. The force of attraction will be greatest between the spheres in (c) set A and C.

A

$$F_g \propto \frac{m_1 m_2}{r^2}$$
$$F_g \propto \frac{(32\ \text{kg})(25\ \text{kg})}{(20\ \text{cm})^2}$$
$$F_g \propto \frac{2.0\ \text{kg}^2}{\text{cm}^2}$$

B

$$F_g \propto \frac{m_1 m_2}{r^2}$$
$$\propto \frac{(80\ \text{kg})(20\ \text{kg})}{(40\ \text{cm})^2}$$
$$\propto \frac{1.0\ \text{kg}^2}{\text{cm}^2}$$

C

$$F_g \propto \frac{m_1 m_2}{r^2}$$
$$\propto \frac{(90\ \text{kg})(10\ \text{kg})}{(15\ \text{cm})^2}$$
$$\propto \frac{4.0\ \text{kg}^2}{\text{cm}^2}$$

14. The gravitational force between spheres is 4.17×10^{-10} N.

$$F_g = G\frac{m_1 m_2}{r^2}$$
$$F_g = \left(6.67\times10^{-11}\ \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2}\right)\frac{(20\ \text{kg})(20\ \text{kg})}{(8.00\ \text{m})^2}$$
$$F_g \cong 4.17\times10^{-10}\ \text{N}$$

15. The force between the spheres will be 1.67×10^{-9} N.

$$F_g = G\frac{m_1 m_2}{r^2}$$
$$F_g = \left(6.67\times10^{-11}\ \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2}\right)\frac{(20\ \text{kg})(20\ \text{kg})}{(4.00\ \text{m})^2}$$
$$F_g \cong 1.67\times10^{-9}\ \text{N}$$

16. The spheres would have to be 11.3 m apart to maintain the gravitational force between them.

$$r = \sqrt{\frac{Gm_1m_2}{F_g}}$$
$$r = \sqrt{\frac{(6.67\times10^{-11}\ \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2})(40.0\ \text{kg})(20.0\ \text{kg})}{4.17\times10^{-10}\ \text{N}}}$$
$$r \cong 11.3\ \text{m}$$

17. The distance between the Sun and Mars is 1.52 AU.

$$\left(\frac{T_{\text{Mars}}}{T_{\text{Earth}}}\right)^2 = \left(\frac{r_{\text{Mars}}}{r_{\text{Earth}}}\right)^3$$
$$r_{\text{Mars}} = r_{\text{Earth}}\left(\sqrt[3]{\left(\frac{T_{\text{Mars}}}{T_{\text{Earth}}}\right)^2}\right)$$
$$r_{\text{Mars}} = 1\ \text{AU}\left(\sqrt[3]{\left(\frac{686\ \text{d}}{365\ \text{d}}\right)^2}\right)$$
$$r_{\text{Mars}} \cong 1.52\ \text{AU}$$

18. The satellite is 1.84×10^8 m from Earth.

$$\left(\frac{T_{\text{satellite}}}{T_{\text{Moon}}}\right)^2 = \left(\frac{r_{\text{satellite}}}{r_{\text{Moon}}}\right)^3$$
$$r_{\text{satellite}} = r_{\text{Moon}}\left(\sqrt[3]{\left(\frac{T_{\text{satellite}}}{T_{\text{Moon}}}\right)^2}\right)$$
$$r_{\text{satellite}} = 3.84\times10^8\ \text{m}\left(\sqrt[3]{\left(\frac{9.1\text{d}}{27.3\text{d}}\right)^2}\right)$$
$$r_{\text{satellite}} \cong 1.84\times10^8\ \text{m}$$

19. The mass of the larger sphere is 50 kg.

$$m_2 = \frac{F_g r^2}{Gm_1}$$
$$m_2 = \frac{(2.50\times10^{-8}\ \text{N})(1.05\ \text{m})^2}{\left(6.67\times10^{-11}\ \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2}\right)(8.2\ \text{kg})}$$
$$m_2 \cong 5.0\ \times10^1\ \text{kg}$$

20. (a) The period of the object is 32 years.

$$\left(\frac{T_{\text{object}}}{T_{\text{Earth}}}\right)^2 = \left(\frac{r_{\text{object}}}{r_{\text{Earth}}}\right)^3$$
$$T_{\text{object}} = T_{\text{Earth}}\sqrt{\left(\frac{r_{\text{object}}}{r_{\text{Earth}}}\right)^3}$$
$$T_{\text{object}} = 1\ \text{a}\sqrt{\left(\frac{10\ \text{AU}}{1\ \text{AU}}\right)^3}$$
$$T_{\text{object}} \cong 32\ \text{a}$$

(b) The speed of the object is 9.41×10^3 m/s.

$$v = \sqrt{\frac{Gm_{\text{Sun}}}{r}}$$
$$v = \sqrt{\frac{(6.67\times10^{-11}\ \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2})(1.99\times10^{30}\ \text{kg})}{1.49\times10^{\text{[illegible]}}\ \text{m}}}$$
$$v \cong 9.44\times10^3\ \frac{\text{m}}{\text{s}}$$

BLM 13-3: Chapter 13 Test/Assessment

Answers

1. **(a)** simple harmonic motion, periodic, directly proportional

(b) increase

(c) the mass is at the maximum displacement from the equilibrium position

(d) the angle of displacement is less than 15° from the equilibrium position

(e) the force of gravity acting on the mass of pendulum bob

2. **(a)** The spring constant is 6.8×10^2 N/m.

$F_{\text{spring}} = F_{\text{g}}$

$kx = mg$

$k = \dfrac{mg}{x}$

$k = \dfrac{(2.7\ \text{kg})\left(9.81\ \frac{\text{m}}{\text{s}^2}\right)}{3.9 \times 10^{-2}\ \text{cm}}$

$k = 6.8 \times 10^2$ N/m

(b) The frequency of oscillation is 2.5 Hz.

$f = \dfrac{1}{2\pi}\sqrt{\dfrac{k}{m}}$

$f = \dfrac{1}{2\pi}\sqrt{\dfrac{\left(6.8 \times 10^2\ \frac{\text{N}}{\text{m}}\right)}{2.7\ \text{kg}}}$

$f = 2.5$ Hz

3. **(a)** The spring constant is 2.7 N/m.

$f = \dfrac{1}{2\pi}\sqrt{\dfrac{k}{m}}$

$k = m(2\pi f)^2$

$k = \left(3.0 \times 10^{-4}\ \text{kg}\right)\left[2\pi(15\ \text{Hz})\right]^2$

$k = 2.7$ N/m

(b) The frequency of oscillation would be 26 Hz.

Since $f \propto \sqrt{\dfrac{1}{m}}$, if m is $\frac{1}{3}$ of the value in part (a), then f increases by a factor of $\sqrt{3}$.

$f = \sqrt{3}\,(15\ \text{Hz})$

$f = 26$ Hz

4. **(a)** The string will have to be 0.994 m.

$T = 2\pi\sqrt{\dfrac{l}{g}}$

$l = \dfrac{gT^2}{4\pi^2}$

$l = \dfrac{\left(9.81\ \frac{\text{m}}{\text{s}^2}\right)(2\ \text{s})^2}{4\pi^2}$

$l = 0.994$ m

(b) The clock will run slower.

Since $T = 2\pi\sqrt{\dfrac{l}{g}}$, the longer l is, the greater will be the period.

5. **(a)** The frequency of oscillation is 0.61 Hz.

$f = \dfrac{1}{2\pi}\sqrt{\dfrac{g}{l}}$

$f = \dfrac{1}{2\pi}\sqrt{\dfrac{9.81\ \frac{\text{m}}{\text{s}^2}}{0.66\ \text{m}}}$

$f = 0.61$ Hz

(b) The speed at the lowest point of the swing is 0.53 m/s.

At lowest point of swing, all the gravitational potential energy of the bob is converted to kinetic energy.

First calculate Δh to find gravitational potential energy.

Using sine law, $\dfrac{\sin 90^\circ}{0.66\ \text{m}} = \dfrac{\sin 78^\circ}{0.66\ \text{m} - \Delta h}$

$\Delta h = (0.66\ \text{m})(1 - \sin 78^\circ)$

$\Delta h = 0.0144$ m

From conservation of total energy, $E_{\text{k}} = E_{\text{g}}$.

$\frac{1}{2}mv^2 = mg\Delta h$

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

$v = \sqrt{2\left(9.81\ \frac{\text{m}}{\text{s}^2}\right)(0.0144\ \text{m})}$

$v = 0.53$ m/s

(c) The total energy of the system is 4.4×10^{-2} J.

At lowest point of swing, all the energy of the system is kinetic energy.

$E_k = \frac{1}{2}mv^2$

$E_k = \frac{1}{2}(0.310 \text{ g})(0.53 \ \frac{\text{m}}{\text{s}})^2$

$E_k = 4.4 \times 10^{-2}$ J

BLM 14-6: Chapter 14 Test/ Assessment

1. **(a)** The second charge is positive.

   (b)

$$\left|\vec{F}_Q\right| = k\frac{q_1 q_2}{r^2}$$

$$r = \sqrt{\frac{kq_1 q_2}{\left|\vec{F}_Q\right|}}$$

$$r = \sqrt{\frac{(8.99 \times 10^9 \ \frac{\text{N}\cdot\text{m}^2}{\text{C}^2})(9.0 \times 10^{-6} \ \text{C})(4.0 \times 10^{-6} \ \text{C})}{0.60 \text{ N}}}$$

$r = 0.73$ m (choosing positive root for distance)

2.(a) Attractive, since the charges have opposite signs

(b) Repulsive, since the charges will now have the same sign

(c) When the objects touch, they share the excess charge equally. Therefore, each object will have a charge of $\frac{-4.0 \text{ nC} + (+8.0 \text{ nC})}{2} = 2.0 \text{ nC}$. Taking into account the changes in the charges and in the distance between them

$$F_{\text{final}} = 3.0 \text{ N}\left(\frac{2.0 \text{ nC}}{4.0 \text{ nC}}\right)\left(\frac{2.0 \text{ nC}}{8.0 \text{ nC}}\right)\left(\frac{d}{0.5d}\right)^2$$

$$F_{\text{final}} = 1.5 \text{ N}$$

3. Since $F_Q \propto 1/r^2$, $F_Q = K(1/r^2)$, where K represents the factor kq_1q_2. This equation has the form $y = mx$. Plotting F_Q versus $1/r^2$ will produce a straight line that passes through the origin and has slope K.

4.

Force	Similar property	Unique property
electric	• might be attractive • decreases with distance	• can have either postive or negative point source
gravitational	• might be attractive • decreases with distance	• can *only* be attractive
magnetic	• might be attractive • decreases with distance	• no evidence of a monopole as a point source

5. The gravitational force on the object will be 98 N.

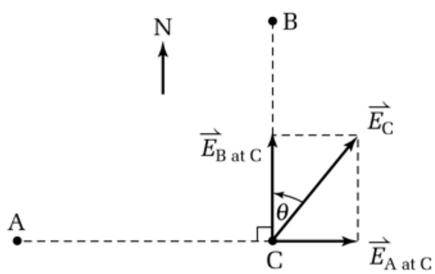
$$\left|\vec{F}_g\right| = F_{surface}\left(\frac{R_J}{R_J + 2.000\times10^6\ \text{m}}\right)^2$$

$$\left|\vec{F}_g\right| = mg\left(\frac{7.18\times10^7\ \text{m}}{7.18\times10^7\ \text{m} + 2.000\times10^6\ \text{m}}\right)^2$$

$$\left|\vec{F}_g\right| = (4.0\ \text{kg})(26\ \text{N})(0.945)$$

$$\left|\vec{F}_g\right| = 98\ \text{N}$$

6. The electric field at C is 4.7×10^8 N/C in a direction 43° east of north.



At point C

$$\left|\vec{E}_A\right| = \left(9.0\times10^9\ \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\right)\left(\frac{56\times10^{-6}\ \text{C}}{(4.0\times10^{-2}\ \text{m})^2}\right)$$

$$\vec{E}_A = 3.15\times10^8\ \frac{\text{N}}{\text{C}}\text{[east]}$$

$$\left|\vec{E}_B\right| = \left(8.99\times10^9\ \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\right)\left(\frac{34\times10^{-6}\ \text{C}}{(3.0\times10^{-2}\ \text{m})^2}\right)$$

$$\vec{E}_B = 3.40\times10^8\ \frac{\text{N}}{\text{C}}\text{[north]}$$

$$E_{net}{}^2 = \left(3.15\times10^8\ \frac{\text{N}}{\text{C}}\right)^2 + \left(3.40\times10^8\ \frac{\text{N}}{\text{C}}\right)^2$$

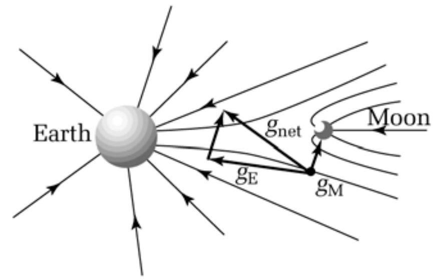
$$E_{net} = 4.6\times10^8\ \frac{\text{N}}{\text{C}}$$

$$\tan\theta = \frac{3.15\times10^8\ \frac{\text{N}}{\text{C}}}{3.40\times10^8\ \frac{\text{N}}{\text{C}}}$$

$$\tan\theta = 0.926$$

$$\theta = 43^\circ$$

7. **(a)**



(b) For any point at a distance r_1 from Earth and r_2 from the Moon, the vector for Earth's gravitational field intensity is $\vec{E}_{Earth} = \frac{Gm_{Earth}}{r_1^2}$ [toward Earth] and the vector for the Moon's gravitational field intensity is $\vec{E}_{Moon} = \frac{Gm_{Moon}}{r_2^2}$ [toward the Moon]. Add these two vectors. The resultant gravitational field vector will have the same direction as the field line through the point, as shown in the previous diagram.

8. **(a)** The amount of work done is 7.8×10^{-7} J.

$$W = q\Delta V$$

$$W = (2.0\times10^{-12}\ \text{C})\left(\frac{\left(8.99\times10^9\ \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\right)(-6.2\times10^{-6}\ \text{C})}{7.2\times10^{-2}\ \text{m}} - \frac{\left(8.99\times10^9\ \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}\right)(-6.2\times10^{-6}\ \text{C})}{4.8\times10^{-2}\ \text{m}}\right)$$

$$W = 2.0\times10^{-12}\ \text{C}(3.87\times10^5\ \text{V})$$

$$W = 7.8\times10^{-7}\ \text{J}$$

(b) $V_{AB} = 3.9\times10^5$ V

(c) Since $V = \frac{kq}{r}$, B has the higher potential difference, as it is farther away from the negative charge and thus has a smaller negative value.

BLM 16-7: Chapter 16 Test/Assessment Answers

1. (d)

2. (c)

3. (c)

4. (d)

5. (d)

6. (c)

7. (c)

8. (c)

9. (b)

10. The current flows in the direction of red arrow. Use the right-hand rule for generator effect.

11. The direction is opposite that of the green arrows. Use the same right-hand rule, but with the variation described on textbook page 45.

12. They are opposite to one another.

13. In a generator, there is always a force present that opposed the motion of the conductor.

14. Lenz's law states that whenever a current is induced, its direction is such that it will create a force that will oppose the motion that originally produced the current.

15. It will be easier to turn because less energy is needed to counter the force opposing the motion that creates the small current (Lenz's law).

16. Electric motors produce back *emf*, which increases the resistance and reduces the current when the motors spin at their optimum speed. The back *emf* is acting against the input voltage and it causes the motor to reach a terminal constant speed of rotation. The faster you make it spin by increasing the voltage, the more back *emf*.

17. The more load placed on a motor, the less back *emf* and the less resistance. Therefore, more current will flow.

BLM 18-3: Chapter 18 Test/Assessment

Part 1 Multiple-Choice Answers

1. (d)
2. (b)
3. (a)
4. (c)
5. (e)
6. (b)
7. (a)

Part 2 Full-Solution Answer

The wavelength of the exciting photons is 1.9×10^{-12} m.

First, find the relativistic kinetic energy.

$$mc^2 = m_0c^2 + E_k$$

$$E_k = mc^2 - m_0c^2$$

$$E_k = \left(\frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}\right)c^2 - m_0c^2$$

$$E_k = m_0c^2\left(\frac{1}{\sqrt{1-\frac{v^2}{c^2}}} - 1\right)$$

$$E_k = \left(9.11\times10^{-31}\text{ kg}\right)\left(3.00\times10^{8}\,\frac{\text{m}}{\text{s}}\right)^2\left(\frac{1}{\sqrt{1-\frac{(0.90c)^2}{c^2}}} - 1\right)$$

$$E_k = 1.0611\times10^{-13}\,\text{J}$$

Next, find the wavelength of the photons.

$$E_k = hf - W$$

$$E_k + W = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{E_k + W}$$

$$\lambda = \frac{\left(6.63\times10^{-34}\,\cancel{\text{J}}\cdot\cancel{\text{s}}\right)\left(3.00\times10^{8}\,\frac{\text{m}}{\cancel{\text{s}}}\right)}{1.0611\times10^{-13}\,\cancel{\text{J}} + 5.0\,\cancel{\text{eV}}\left(1.6\times10^{-19}\,\frac{\cancel{\text{J}}}{\cancel{\text{eV}}}\right)}$$

$$\lambda = 1.9\times10^{-12}\text{ m}$$

BLM 19-3: Chapter 19 Test/Assessment

Answers

1. (c)
2. (e)
3. (b)
4. (b)
5. (a)

BLM 20-5: Chapter 20 Test/Assessment

Answers

1. **(a)**

$$\Delta m = \left(m_p + m_n\right) - \left(m_{atom} - m_e\right)$$

$$\Delta m = 26(1.007\ 276\text{ u}) + 31(1.008\ 665\text{ u}) - [56.935\ 396\text{ u} - 26(0.000549\text{ u})]$$

$$\Delta m = 57.457\ 791\text{ u} - 56.921\ 122\text{ u}$$

$$\Delta m = 0.536\ 669\text{ u}$$

(b)

$$\Delta E = \Delta mc^2$$

$$\Delta E = \left(0.536\ 669\,\cancel{\text{u}}\right)\left(1.6605\times10^{-27}\,\frac{\text{kg}}{\cancel{\text{u}}}\right)\left(3.00\times10^{8}\,\frac{\text{m}}{\text{s}}\right)^2$$

$$\Delta E = \frac{8.0202\times10^{-11}\,\cancel{\text{J}}}{1.602\times10^{-13}\,\frac{\cancel{\text{J}}}{\text{MeV}}}$$

$$\Delta E = 5.0064\times10^{8}\,\text{eV}$$

$$\Delta E_{\text{nucleon}} = \frac{5.0064\times10^{2}\,\text{MeV}}{57}$$

$$\Delta E_{\text{nucleon}} = 8.78\text{ MeV per nucleon}$$

2. Find the total binding energy of the nucleus in eV.

$$\left(208\ \cancel{\text{nucleons}}\right)\left(7.93\ \frac{\text{MeV}}{\cancel{\text{nucleon}}}\right) = 1649.44\text{ MeV}$$

$$\left(1649.44\ \cancel{\text{MeV}}\right)\left(\frac{1\times10^{6}\text{ eV}}{\cancel{\text{MeV}}}\right) = 1.649\ 44\times10^{9}\text{ eV}$$

Convert into joules.

$$\left(1.649\ 44\times10^{9}\,\cancel{\text{eV}}\right)\left(1.602\times10^{-19}\ \frac{\text{J}}{\cancel{\text{eV}}}\right)$$

$$= 2.642\ 40\times10^{-10}\text{ J}$$

Find the mass equivalent of the energy.

$$m = \frac{\Delta E}{c^2}$$

$$m = \frac{2.64240 \times 10^{-10}\ \text{J}}{(3.0 \times 10^{8}\ \frac{\text{m}}{\text{s}})^2}$$

$$m = 2.93600 \times 10^{-27}\ \text{kg}$$

Convert into atomic mass units.

$$\left(2.936\ 00 \times 10^{-27}\ \text{kg}\right)\left(\frac{1\ \text{u}}{1.6605 \times 10^{-27}\ \text{kg}}\right)$$

1.768 14 u

Subtract the mass equivalent of the binding energy from the sum of the masses of the equivalent number of neutrons and protons.

$$\text{m}_{\text{Pb}} = 126(1.008\ 665\ \text{u}) + 82(1.007\ 276\ \text{u}) + 82(0.000\ 549\ \text{u}) - 1.768\ 14$$

$$\text{m}_{\text{Pb}} = 207.9653\ \text{u}$$

3. $^{234}_{92}\text{U} \rightarrow {}^{230}_{90}\text{Th} + {}^{4}_{2}\text{He}$

4.

$$N = N_{\text{o}}\left(\frac{1}{2}\right)^{\frac{\Delta t}{T_{\frac{1}{2}}}}$$

$$N = 30\ \text{g}\left(\frac{1}{2}\right)^{\frac{75\ \text{h}}{15\ \text{h}}}$$

$$N = 0.94\ \text{g}$$

5.

$$N = N_{\text{o}}\left(\frac{1}{2}\right)^{\frac{\Delta t}{T_{\frac{1}{2}}}}$$

$$\frac{1}{64} = \left(\frac{1}{2}\right)^{\frac{\Delta t}{12.5\ \text{a}}}$$

$$\left(\frac{1}{2}\right)^{6} = \left(\frac{1}{2}\right)^{\frac{\Delta t}{12.5\ \text{a}}}$$

$$6 = \frac{\Delta t}{12.5\ \text{a}}$$

$$\Delta t = 75\ \text{a}$$

6. Some smoke detectors contain a radioisotope that decays by emitting alpha particles. These alpha particles ionize molecules in the air. The negative ions are attracted to the positive electrode and the positive ions are attracted to the negative electrode. In other words, the gas in the detector conducts electricity. The current that passes through is monitored. Any soot particles present in the air absorb and neutralize the ions. The current decreases as a result, triggering the alarm. Student diagrams should resemble Figure 20.11 in the student textbook.

BLM 21-5: Chapter 21 Test/Assessment

Answers

1. (a) A chain reaction is a self-sustaining series of reactions, in which one reaction stimulates further reactions. An example is nuclear fission, in which the neutrons emitted by one fission even can stimulate further fission events.

(b) When a nucleus of uranium-235 absorbs a neutron, the nucleus splits into two smaller nuclei and some neutrons. There are a number of possible fission products—the only restriction is that the total mass number of the products must remain the same as the total mass number of the reactants. For example, the fission of uranium-235 can produce an atom of barium-141, an atom of krypton-92, and three neutrons; or it can produce an atom of rubidium-90, an atom of cesium-144, and two neutrons. There are a great number of other possibilities.

2. (a) The incomplete equation shows a fusion reaction.

(b) $^{2}_{1}\text{H} + {}^{3}_{1}\text{H} \rightarrow {}^{4}_{2}\text{He} + {}^{1}_{0}\text{n} + \text{thermal energy}$

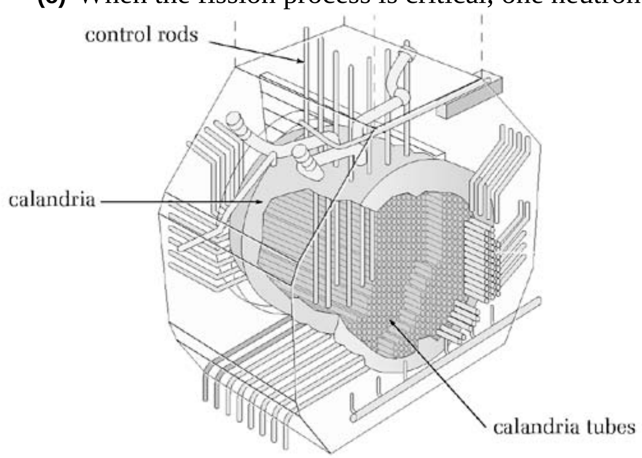
3.

- **Calandria tubes** — sealed calandria tubes hold the zirconium alloy tubes, which contain the fuel pellets.
- **Control rods** — rods made of boron or cadmium are lowered into or raised out of the reactor core, absorbing the right number of neutrons to maintain the chain reaction at a critical level.
- **Calandria** — the sealed calandria contains the fuel rods and heavy water moderator. It is one of the many levels of containment for the CANDU reactor.

4. **(a)** The moderator slows down the fast neutrons emitted by fissioning nuclei, ensuring that the neutrons will cause further fissions, and thus maintaining the chain reaction at a critical level.

(b) The isotopes of cadmium and boron used in control rods have an exceptional ability to absorb neutrons, thus slowing down the chain reaction.

(c) When the fission process is critical, one neutron



from each fission event causes one more fission event. At the critical level, the reaction is sustained at a constant rate. When the process is subcritical, fewer than one neutron from each fission event causes a further fission event. The reaction slows down and will eventually cease. When the process is supercritical, more than one neutron from each fission event causes a further fission event. As a result, the chain reaction speeds up very quickly. It is important to maintain the chain reaction in a reactor at the critical level so that energy is produced at a constant rate. The chain reaction does not stop, nor does it escalate out of control.

5. CANDU reactors use heavy water as a moderator. Heavy water is an excellent moderator, meaning it slows down enough neutrons to sustain a chain reaction at the critical level when natural uranium is used as a fuel. When other moderators are used, enriched uranium (containing an increased percentage of uranium-235) must be used as fuel to ensure the chain reaction remains critical.

6. In fission, a large nucleus splits into two smaller nuclei. In fusion, two small nuclei come together to form one larger nucleus. In both cases, the binding energy per nucleon of the product(s) is larger than the binding energy per nucleon of the reactant(s). This means that the total mass of the product(s) is smaller than the total energy of the reactant(s). The difference in mass is converted into energy via Einstein’s equation, $\Delta E = \Delta mc^2$. Because c^2 is such an enormous factor, even a small change in mass translates to a large change in energy.

7. **(a)** Compared to fission, fusion produces more energy per gram of fuel, the fuel itself is more plentiful, and the byproducts of the chain reaction are not nearly as dangerous.