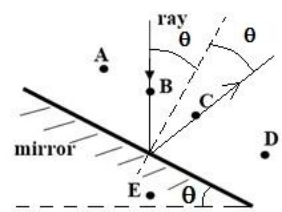
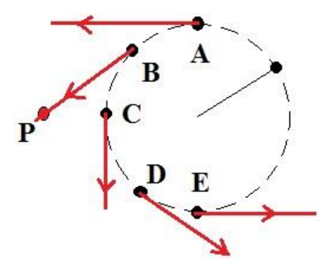
2012 PhysicsBowl Solutions

#	Ans	#	Ans	#	Ans	#	Ans	#	Ans
1	B	11	B	21	A	31	A	41	C
2	C	12	D	22	B	32	C	42	A
3	B	13	C	23	A	33	E	43	B
4	D	14	B	24	C	34	C	44	D
5	C	15	A	25	D	35	A	45	C
6	E	16	B	26	E	36	D	46	D
7	A	17	C	27	D	37	B	47	C
8	D	18	A	28	E	38	E	48	E
9	D	19	D	29	E	39	A	49	A
10	E	20	E	30	B	40	D	50	B

1. **B…** The lengths in the problem are (A) 0.01 m, (B) 1000 m, (C) 0.001 m, (D) 1.0 m, (E) $1 \times 10^{-9} m$
2. **C…** The ray of light will bounce off the mirror with the same reflected angle as incident angle measured from the normal of the mirror's surface. The figure demonstrates the ray's path.

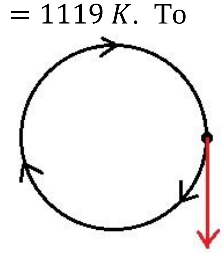


3. **B…** Using unit conversions, we have
$$3.0 \times 10^8 \frac{m}{s} \times \frac{1\ mi}{1600\ m} \times \frac{60\ s}{1\ min} \times \frac{60\ min}{1\ hr} \times \frac{24\ hr}{1\ dy} \times \frac{7\ dy}{1\ wk} = 1.13 \times 10^{11} \frac{mi}{wk}$$
4. **D…** The period and frequency are related as $T = \frac{1}{f} = \frac{1}{2.00\ Hz} = 0.50\ s$
5. **C…** From rules of significant digits when multiplying, the result has an equal number of sig. figs as the value with the fewest sig figs. Here, the values have 4,3, and 3 sig. figs meaning that the result also must have 3 significant digits. Hence, $V = LWH = (13.34\ cm)(8.45\ cm)(3.36\ cm) = 3.79 \times 10^2\ cm^3$
6. **E…** Visible light is in the wavelength range of $400\ nm - 700\ nm$ with violet at the $400\ nm$ end.
7. **A…** From Newton's Second Law, $F_{net} = ma = (5.00\ kg)\left(2.00\ {}^{m}/_{s^2}\right) = 10.0\ N$
8. **D…** From constant acceleration kinematics, one writes $v^2 = v_0^2 + 2a\Delta x \Rightarrow \Delta x = \frac{v^2 - v_0^2}{2a} = \frac{8^2 - 4^2}{2(2)} = 12.0\ m$
9. **D…** The power for a resistor is computed as $P = I^2 R \Rightarrow R = \frac{P}{I^2} = \frac{24.0\ W}{(4.00\ A)^2} = 1.50\ \Omega$
10. **E…** From Newton's Second Law, we have $F_{net} = ma \Rightarrow T - G = F$. Now, $G = mg = (10\ kg)\left(10\ {}^{N}/_{kg}\right) = 100\ N$, $|F| = m|a| = (10\ kg)\left(6.0\ {}^{m}/_{s^2}\right) = 60\ N$. Now, $T - G = F \Rightarrow T = G + F = (100) + (-60) = 40.0\ N$. The minus sign was used on F since the net force is downward (positive chosen upward). Hence, $(T = 40) < (F = 60) < (G = 100)$.



11. **B…** By Newton's First Law, the mass will continue to move horizontally with constant speed. For the object, the trajectories of the object as it twirls counterclockwise are shown for all choices.
12. **D…** "S" is for speed which is for scalar. Impulse, linear momentum, and force are all related by the impulse-momentum theorem, and displacement is a change in position. These last four quantities are all vectors.
13. **C…** By charge quantization, $Q = Ne \Rightarrow N = \frac{Q}{e} \Rightarrow$
$$N = \frac{1.00\ C}{1.6 \times 10^{-19} \frac{C}{e^-}} = 6.25 \times 10^{18}\ e^-$$
14. **B…** At the junction, there are two branches each with a resistor, so these are in parallel. $\frac{1}{R_{par}} = \frac{1}{R} + \frac{1}{R} \Rightarrow R_{par} = \frac{R}{2}$. This parallel branch is in series with another resistor. So, $R_{eq} = R + \frac{R}{2} = \frac{3}{2}R$.

15. **A…** The phases of the Moon are : New Moon – Waxing Crescent – First Quarter – Waxing Gibbous – Full Moon – Waning Gibbous – Last (or Third) Quarter – Waning Crescent – New Moon ….
16. **B…** The work done by the force on the box is $W = Fd\cos\theta = (50\ N)\ (6.0\ m)\cos 20^{\circ} = 282\ J$
17. **C…** The slope at a given time of the position vs. time graph gives the velocity at that time. Negative velocity means negative local slope. This occurs everywhere from $2.5\ s < t < 7.5\ s$.
18. **A…** The force of gravity acting on the Earth from the object is $10\ N$ as it is the same as the gravitational force acting on the object from the Earth. However, while the object falls a distance of $1.0\ m$, the Earth moves infinitesimally because of its large mass. Hence, $W = Fd\cos\theta \cong 0\ J$.
19. **D… METHOD #1:** We can write the kinetic energy of a point mass as $KE = \frac{1}{2}mv^2 = \frac{p^2}{2m}$ and so,
$\Delta KE = \frac{p_f^2}{2m} - \frac{p_i^2}{2m} = \frac{14^2}{2(4)} - \frac{6^2}{2(4)} = 24.5 - 4.5 = 20\ J$
METHOD #2: Knowing the linear momentum, we can find the speed of the particle as $p = mv\ \Rightarrow v = \frac{p}{m}$ meaning $v_f = \frac{p_f}{m} = \frac{14}{4} = 3.5\ \frac{m}{s}$ and $v_i = \frac{p_i}{m} = \frac{6}{4} = 1.5\ \frac{m}{s}$. So, $\Delta KE = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = 24.5 - 4.5 = 20\ J$
20. **E…** This is a statement of the Heisenberg Uncertainty Principle
21. **A…** Xenon gas is much denser than the surrounding air. As a result, when released, the balloon sinks immediately to the ground. For a video demonstration: http://www.youtube.com/watch?v=QLrofyj6a2s
22. **B…** The question asks for the net force acting on the mass. This is found as $F_{net} = ma = m\frac{v^2}{r}$ where there is radial acceleration as the object moves in a circle. Hence, $F_{net} = m\frac{v^2}{r} = (4)\frac{3.24^2}{0.75} = 56\ N$.
23. **A…** From Newton's Third Law, the force that M_1 exerts on M_2 has the same magnitude of the force that M_2 exerts on M_1. By Newton's Second Law, $a = \frac{F}{m}$, the less massive object undergoes a greater acceleration!.
24. **C…** Using linear momentum conservation, we have $\Delta p_{sys} = 0\ \Rightarrow\ p_f = p_i\ \Rightarrow$
$M_1V_{1f} + M_2V_{2f} = M_1V_{1i} + M_2V_{2i}\ \rightarrow (3)(-1) + (5)V_{2f} = (3)(5) + (5)(-2)\ \Rightarrow\ -3 + (5)V_{2f} = 5$
where we have taken "to the left" as the positive direction. Finally, $(5)V_{2f} = 8\ \Rightarrow V_{2f} = 1.60\ \frac{m}{s}$.
25. **D…** The hour hand on a standard clock makes a complete circle every 12 hours. Hence, $\omega = \frac{\Delta\theta}{\Delta t} = \frac{2\pi\, rad}{12\, hr}$.
Using unit conversions, we have $\omega = \frac{2\pi\, rad}{12\, hr} \times \frac{1\, hr}{60\, min} \times \frac{1\, min}{60\, s} = 1.45\ \times 10^{-4}\ \frac{rad}{s}$
26. **E…** The horizontal component of the velocity does not change during flight, but the vertical component is changing due to gravity. This means that the speed is found from the Pythagorean Theorem with
$v_{tot} = \sqrt{v_x^2 + v_y^2}\ \Rightarrow\ 20^2 = \sqrt{10^2 + v_y^2}\ \Rightarrow\ v_y^2 = 300\ \Rightarrow\ v_y = -17.3\ \frac{m}{s}$. The minus sign indicates downward motion. Using constant acceleration kinematics, $v_y = v_{0y} + a_y t\ \Rightarrow\ -17.3 = 0 + (-10)t\ \Rightarrow$
$t = 1.73\ s$
27. **D…** Using the ideal gas equation, $PV = nRT$, one could determine the volume of the gas… or write the ratio of the ideal gas equation as $\frac{P_fV_f}{P_iV_i} = \frac{nRT_f}{nRT_i}\ \Rightarrow (3)(1) = (1)(1)\frac{T_f}{T_i} \Rightarrow\ T_f = 3T_i$. The issue is that these temperatures must be in Kelvin! So, $T_i = 100 + 273 = 373K$. This makes $T_f = 3(373) = 1119\ K$. To put this back into Celsius, we have $T_f = 1119 - 273 = 846$.
28. **E…** The magnetic field lines form concentric circles around the wire with the right-hand rule of the right thumb along the current and the fingers wrapping in the sense of the field. At a given location, the field direction is tangent to the circle. For this configuration, the field lines form clockwise circles and therefore at P, the field is directed straight downward as in the figure.



29. **E… METHOD #1:** For simplicity, we take an example of a track length being 80

meters. To complete two laps with an average speed of 80 $\frac{m}{s}$ means that the vehicle has exactly 2.0 seconds to complete both laps. For the first lap, the time is $t = \frac{L}{v} = \frac{80}{50} = 1.60\ s$. This means that the second lap must be completed in $2.00 - 1.60 = 0.40\ s$. Hence, $V = \frac{L}{t} = \frac{80}{0.40} = 200\ \frac{m}{s}$.

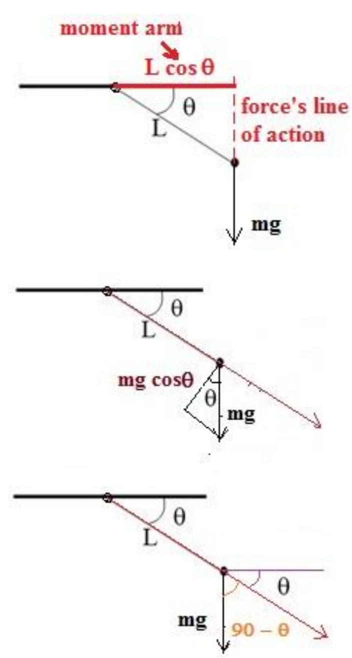
METHOD #2: For a general track length L, we can write for part 1: $v = \frac{L}{t} \Rightarrow 50 = \frac{L}{t_1}$ and for the whole trip, $80 = \frac{2L}{t_1+t_2}$. The second trip gives : $V = \frac{L}{t_2}$. Rewriting the speed equations for time, we have $50 = \frac{L}{t_1} \Rightarrow t_1 = \frac{L}{50}$ and $t_2 = \frac{L}{V}$. Substituting this into the expression for the whole trip, we find $80 = \frac{2L}{t_1+t_2} = \frac{2L}{\frac{L}{50}+\frac{L}{V}} = \frac{2}{\frac{1}{50}+\frac{1}{V}} = \frac{100V}{50+V}$. Solving for V, we have $\frac{100V}{50+V} = 80 \Rightarrow 4000 + 80V = 100V \Rightarrow 4000 = 20V \Rightarrow V = 200\ \frac{m}{s}$.

30. B… From the double slit expt., we have for the bright fringes $d \sin\theta = m\lambda$ where m is the order of the bright fringe. The maximum value for m occurs when $\theta = 90^\circ$ leading to $m_{max} = \frac{d}{\lambda} = \frac{42.4\times10^{-6} m}{550\times10^{-9}} = 77.1$ Since there can only be integer orders viewed, the maximum value is the 77th order bright fringe.

31. A… The potential energy associated with any two point charges is given by $U = \frac{kq_1q_2}{r}$ where the zero of potential energy is taken as $r \to \infty$. The work done in this situation goes into the potential energy of the charges configuration (there is no KE). The potential energy of the configuration is found from the sum of the potential energy associated with each pair of charges. That means we have $U_{Total} = 0 = \frac{kQQ_2}{R/2} + \frac{kQQ_2}{R/2} + \frac{kQQ}{R}$. Solving for Q_2 gives $2\frac{kQQ_2}{R/2} = -\frac{kQQ}{R} \Rightarrow 4Q_2 = -Q \Rightarrow Q_2 = -\frac{Q}{4}$.

32. C… The first Nobel Prize in physics went to Wilhelm Röntgen in 1901 for his work with X-rays. Isaac Newton never won a Nobel Prize and Albert Einstein did win a Nobel Prize in 1921. Marie Curie was the first woman to win the Nobel Prize in physics in 1903. James Chadwick won the Nobel Prize in 1935.

33. E… The rotational kinetic energy is computed as $\frac{1}{2}I\omega^2$ with $I = \frac{2}{5}mR^2$ for the axis of rotation through its center giving $KE_{rot} = \frac{1}{2}\left(\frac{2}{5}mR^2\right)\omega^2 = \frac{1}{5}mv^2$ since $v = \omega R$ for rolling motion. Hence, $\frac{1}{5}mv^2 = 20 \Rightarrow mv^2 = 100$ meaning that the translational kinetic energy is given by $KE_{trans} = \frac{1}{2}mv^2 = \frac{1}{2}(100) = 50\ J$



34. C… The calculation of torque is $Fd\sin\theta$ but the angle in the equation is NOT necessarily the angle labeled in the picture. The figures show three interpretations for calculating the torque which shows how we end up with the torque being $mgL\cos\theta$. In the final picture, the calculation is $\tau = Fd\sin\text{"}\theta\text{"} = mgL\sin(90-\theta) = mgL\cos\theta$

35. A… METHOD #1: Starting with the object at infinity, the image for this lens would be at the focal point on the other side of the lens. As the object is moved inward to the center of curvature (twice the focal length), the image position moves between the focal point and the center of curvature. When the object is at the center of curvature, so is the image. At this point, the distance between the image and object is $4f$. As the object moves inside the center of curvature, the image appears between the center of curvature and infinity. In other words, the object and image "flip" locations from when the object came in from infinity (e.g., object at focus means image at infinity). This means that the closest distance between object and image is $4f$.

METHOD #2: Using a more mathematical approach, one can write that $p + q = 3f \to q = 3f - p$. Using the basic lens expression, we have $\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \to \frac{1}{f} = \frac{1}{p} + \frac{1}{3f-p} \to \frac{1}{f} = \frac{3f}{(3f-p)p}$. Rearranging this expression (clearing denominators), we have $3fp - p^2 = 3f^2 \to p^2 - 3fp + 3f^2 = 0$. Using the solution to the quadratic equation yields $p = \frac{3f \pm \sqrt{9f^2 - 12f^2}}{2} = \frac{3}{2}f \pm \frac{f}{2}\sqrt{-3}$. This result is imaginary and there are no real solutions implying that the distance between the object and image being $3f$ is impossible.

36. D… Here, we look at the Lorentz Force Law $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$. Since the electric force is out of the plane of the page, in order for the positive charge to experience no net force (moves with constant velocity), there must be a magnetic force directed into the plane of the page. By the right hand rule, the right fingers point in the direction of the velocity and curl into the direction of the magnetic field, leaving the right thumb to point in the direction of the force. Doing this, we find that only the result of (D) gives the right thumb pointing into the plane of the page.

37. B… METHOD #1: An aluminum atom has an approximate radius of 1 Angstrom (this is best described as a Fermi problem), and so it has an approximate area of $A = \pi R^2 = \pi(1 \times 10^{-10})^2 = \pi \times 10^{-20} m^2$. The area of the nail's head is $A = \pi r^2 = \pi(0.5 \times 10^{-2})^2 = \pi \times 2.5 \times 10^{-5} m^2$. Taking the ratio, we have

$$\pi \times 2.5 \times 10^{-5} \frac{m^2}{surface} \Big/ \pi \times 10^{-20}\, m^2/_{atom} = 2.5 \times 10^{15} \frac{atoms}{surface} \approx 10^{15} \frac{atoms}{surface}$$

METHOD #2: For the truly hard-core student that remembers properties about aluminum… the mass density of aluminum is $2700 \frac{kg}{m^3}$ and aluminum has an atomic mass of approximately $27 \frac{g}{mol}$. So, taking the ratio leads to aluminum having $2700 \frac{kg}{m^3} \Big/ 0.027 \frac{kg}{mol} = 1 \times 10^5 \frac{mol}{m^3}$. Using Avogadro's Number, we find then that we have $1 \times 10^5 \frac{mol}{m^3} \times 6.02 \times 10^{23} \frac{atoms}{mol} = 6.02 \times 10^{28} \frac{atoms}{m^3}$ for the aluminum. Since the top layer of the aluminum is approximately 2 Angstroms thick (approximate diameter of an atom),the volume of the top layer on the cylinder is

$V = \pi r^2 t = \pi(0.5 \times 10^{-2})^2(2 \times 10^{-10}) = 1.57 \times 10^{-14} \frac{m^3}{surface}$. So, finally we compute the number of atoms as $N = \left(6.02 \times 10^{28} \frac{atoms}{m^3}\right)\left(1.57 \times 10^{-14} \frac{m^3}{surface}\right) = 9.5 \times 10^{14} \frac{atoms}{surface} \approx 10^{15} \frac{atoms}{surface}$

38. E… With the time-changing magnetic field, there is an induction by Lenz's Law to oppose the change. This increasing field strength into the plane of the loop results in a counterclockwise-oriented electric field that produces a CCW conventional current in the wire. Using the right-hand rule for the force on a wire in a magnetic field for the right-most wire, we have the right fingers point along the current curling into the page results in the right thumb pointing to the left. Performing the same analysis on each wire element results in forces on each leg directed toward the center, thereby trying to decrease the size of the region receiving magnetic field. The legs of the loop are trying to decrease the area enclosed by the loop

39. A… By closing the switch in the circuit, the light bulbs have been put into parallel, thereby reducing the resistance of the grouping. In order to maintain the same brightness, there must be the same ratio of potential difference for the light bulbs compared to the two resistors in the circuits so that the potential differences do not change. In other words, we write $\frac{I R_{bulb}}{I(r+R)} = \frac{\left(\frac{1}{2}I_2\right)R_{bulb}}{I_2(r+R')}$ where I is the current in the initial circuit and I_2 is the current in the circuit with both bulbs. This expression leads to $\left(\frac{1}{8+26}\right) = \frac{1}{2}\left(\frac{1}{8+R'}\right) \rightarrow 2(8+R') = 34 \rightarrow \quad 8 + R' = 17 \rightarrow \quad R' = 9\,\Omega$

40. D… From the kinetic theory of gases, the rms speed is found as $v = \sqrt{\frac{3RT}{M}}$ where M is the molar mass of the gas. Using the ideal gas equation, we have $PV = nRT \Rightarrow RT = \frac{PV}{n}$ and so we rewrite the rms speed as

$v_{rms} = \sqrt{\frac{3PV}{nM}} = \sqrt{\frac{3PV}{m}}$ where m represents the mass of the gas (# moles * mass/mole = total mass). Lastly, the quantities for pressure, mass, and volume must be converted to MKS units resulting in $P = 3\ atm \times \frac{1.013\times10^5 Pa}{1\ atm} = 3.039 \times 10^5 Pa$, $m = 0.058\ kg$, and $V = 6\ L \times \frac{1\ m^3}{1000\ L} = 6\ \times 10^{-3} m^3$. Finally, we compute the speed as $v_{rms} = \sqrt{\frac{3PV}{m}} = \sqrt{\frac{3(3.039\times10^5)(6\times10^{-3})}{0.058\ kg}} = 307\frac{m}{s}$.

41. **C…** An alpha particle is a helium nucleus, comprised of 2 neutrons and 2 protons.
42. **A…** For radioactive decay, the mathematical expression is given as $N(t) = N_0 e^{-\lambda t}$. The half-life is the time for ½ of the particles to decay. Hence, we have from the decay equation (with $\lambda = 20\ s^{-1}$) $\frac{N_0}{2} = N_0 e^{-\lambda t} \Rightarrow -\lambda t_{\frac{1}{2}} = \ln\frac{1}{2} \Rightarrow t_{\frac{1}{2}} = \left(\frac{\ln 2}{\lambda}\right) \Rightarrow t_{\frac{1}{2}} = \frac{\ln 2}{20} = 0.035\ s.$
43. **B…** Having the net force equaling zero means that there is no linear acceleration of the body. This puts it into translational equilibrium. However, the net force equaling zero is no guarantee that the net torque is also equal to zero, so nothing can be concluded about the rotational motion of the system. The only statement that MUST be true is that the body is in translational equilibrium.
44. **D…** The coefficient of performance is computed as "what you get divided by what you pay for". For the refrigerator, you are paying for energy to be removed from the cold temperature reservoir to the high temperature reservoir and paying for the work done to remove the energy. In equations, this is $cop_{fridge} = \frac{|Q_C|}{|W|}$. For the PV diagram given, the magnitude of the work done is equal to magnitude of the area under PV curve which here is $W = P_0 V_0 = nRT_0$ where T_0 is the temperature at point A in the cycle. For the processes shown, there is heat lost from the cold surroundings in processes AB and BC. For a monatomic ideal gas, the heat associated with these processes is computed as $Q_{BC} = nc_v \Delta T_{BC}$ and $Q_{AB} = nc_p \Delta T_{AB}$. Here, $c_p = \frac{5}{2}R$; $c_v = \frac{3}{2}R$ and $\Delta T_{BC} = 2T_0$; $\Delta T_{AB} = T_0$. Using the ideal gas equation, the temperatures at A,B,C, and D are found as $T_0, 2T_0, 4T_0$, and $2T_0$, respectively, allowing us to find the temperature changes. So, $Q_C = n\left(\frac{3}{2}R\right)(2T_0) + n\left(\frac{5}{2}R\right)(T_0) = \frac{11}{2}nRT_0$. This means that the coefficient of performance is $cop_{fridge} = \frac{\frac{11}{2}nRT_0}{nRT_0} = \frac{11}{2}$.
45. **C…** Linear momentum conservation is applied in this problem. The momentum of the photon is given as $E = pc \Rightarrow p = \frac{E}{c} = \frac{10.0\ eV}{c} \times \frac{c}{3\times10^8\frac{m}{s}} \times \frac{1.6\times10^{-19}C}{1e} = 5.33 \times 10^{-27}\ kg\frac{m}{s}$. Since there is no initial linear momentum, after the particle emission, this condition is maintained and so the remaining atom must have an equal amount of momentum in the opposite direction. This leads to $p = mv \Rightarrow v = \frac{p}{m} = \frac{5.33\times10^{-27}}{4.00\times10^{-26}} = 0.133\frac{m}{s}$.
46. **D…** Using units analysis, we have ${t_{Planck}}^2 = \frac{\hbar G}{c^n} \rightarrow s^2 = (Js)\left(\frac{Nm^2}{kg^2}\right)\frac{s^n}{m^n}$. The Newton is $N = kg\frac{m}{s^2}$ with a Joule written as $J = Nm = kg\frac{m^2}{s^2}$. These substitutions lead to $s^2 = \left(kg\frac{m^2}{s^2}s\right)\left(\frac{kg\frac{m}{s^2}m^2}{kg^2}\right)\frac{s^n}{m^n} = \frac{m^5}{s^3}\frac{s^n}{m^n}$. Rearranging the equation leads to $\frac{s^n}{m^n} = \frac{s^5}{m^5}$ meaning that $n = 5$.
47. **C…** To solve this problem, we need a combination of Bernoulli's Equation along with the Equation of Continuity. The mass flow rate is the same at the top and bottom portion of the pipe, hence we can write $\rho Av = constant$. Since the fluid is ideal, the density is the same throughout, leading to $A_{top}v_{top} = A_{bot}v_{bot} \Rightarrow (10)(9) = (30)v_{bot} \Rightarrow v_{bot} = 3.0\frac{m}{s}$. Now employing Bernoulli's equation for two points along a streamline at the center of the tube, we write $P_B + \frac{1}{2}\rho v_B^2 + \rho g y_B = P_T + \frac{1}{2}\rho v_T^2 + \rho g y_T$. Choosing the location of the lower pipe to be $y_B = 0$, we have $P_B + \frac{1}{2}\rho v_B^2 = P_T + \frac{1}{2}\rho v_T^2 + \rho g y_T \Rightarrow$

$P_B + \frac{1}{2}(1000)(3)^2 = P_T + \frac{1}{2}(1000)(9)^2 + (1000)(10)(2) \Rightarrow$ and so
$P_B - P_T = 40500 + 20000 - 4500 = 56000 = 56\,kPa$.

48. E… From Newton's Second Law, $F_{net} = ma = m\frac{\Delta v}{\Delta t}$. Using mechanical energy conservation for the object-Earth system both before and after the collision to determine the speed of the object when it reaches the ground and when it moves away, we can write $\Delta KE + \Delta PE = 0 \Rightarrow \frac{1}{2}mv^2 - 0 + mg\Delta y = 0 \Rightarrow v = -\sqrt{-2g\Delta y}$**.** The negative sign for the velocity indicates that it is moving downward when it reaches the ground. This results in $v_0 = -\sqrt{2gH}$ for the velocity of the object before hitting the ground with $\Delta y = -H$. Likewise, for the trip upward, we write a similar expression to find $v_f = \sqrt{2g\Delta y} = \sqrt{2g\frac{H}{2}} = \sqrt{gH}$. So, by putting this together, we have $F_{net} = m\frac{\Delta v}{\Delta t} = M\frac{\sqrt{gH}-(-\sqrt{2gH})}{T} = \frac{M}{T}(\sqrt{2}+1)\sqrt{gH} = (\sqrt{2}+1)\frac{M}{T}\sqrt{gH}$.

49. A… When light is polarized like this, it means that there is a right angle between reflected and refracted rays. This means that since the reflected ray is 58°, then the refraction angle is $180^\circ - 90^\circ - 58^\circ = 32^\circ$. Using Snel's Law we write $n_1 \sin\theta_1 = n_2 \sin\theta_2 \;\Rightarrow\; 1.00\sin(58^\circ) = n_2 \sin(32^\circ) \;\Rightarrow$

$$n_2 = \frac{\sin(58^\circ)}{\sin(32^\circ)} = 1.60$$

ALTERNATIVELY: One could recognize this as a problem related to Brewster's Angle. This relation is that $\tan\theta_i = \frac{n_2}{n_1} \rightarrow \tan(58^\circ) = \frac{n_2}{n_1} \rightarrow n_2 = n_1 \tan 58^\circ = 1.00 \tan 58^\circ = 1.60$

50. B … A time-changing electric field has an associated magnetic field. Outside the region of the electric field, this magnetic field is oriented in clockwise circles because there is no Lenz's Law associated with the time changing electric field. So, at the location of the moving electron, there is a magnetic field directed to the left at the instant shown. Using the right-hand rule, with right fingers pointed along the velocity of the electron, the fingers are curled to the left. Since the charge of interest is negative, the hand is flipped 180 degrees resulting in the right thumb pointing into the plane of the page.