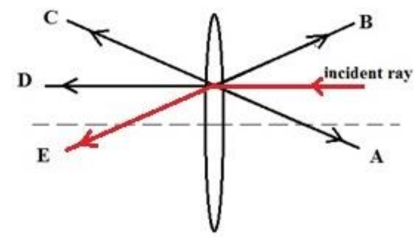
2016 PhysicsBowl Solutions

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

1. **C…** 1 second < 1 minute < 1 day < 1 week < 1 year
2. **A…** The velocity of the object is found from the slope of the line tangent to the point on the position vs. time graph. To have the greatest speed, we are looking for the largest magnitude of slope to the line tangent. The steepest curve on the position vs. time graph shown occurs at time $t = 3.0\ s$.
3. **D…** First, we convert units to obtain $60\frac{km}{hr} \times \frac{1000\ m}{1\ km} \times \frac{1\ hr}{60\ min} \times \frac{1\ min}{60\ s} = 16.7\frac{m}{s}$. Using constant acceleration kinematics then yields $a = \frac{v - v_0}{t} = \frac{16.7 - 0}{4.5} = 3.7\frac{m}{s^2}$.
4. **D…** The simplest way to look at the addition of quantities is to line up the decimal place. That is, we are computing $0.5\mathbf{4} + 5.4 + 54.0 + 540.0 = 599.9\mathbf{4}$. The 4 is bolded as it is the only digit known in the hundredths place since three of the quantities stop at the tenths. Hence, the final value is only kept to the tenths place making $599.9 = 5.999 \times 10^2\ m$ the correct answer.
5. **B…** By performing the free body diagram on the mass m, we have the tension in the string and the gravitational force. Since everything is at rest and not accelerating, we find from Newton's Second Law that $F_{net} = ma \rightarrow T + (-mg) = 0 \ \rightarrow\ T = 60\ N$. Note that for the mass on the ground, there is an additional normal force acting!
6. **D…** Using constant acceleration kinematics, we have $y = y_0 + v_0 t + \frac{1}{2}at^2 \ \rightarrow$ $0 = H + (-20)(2) + \frac{1}{2}(-10)(2)^2 \ \rightarrow\ H = 40 + 20 = 60\ m$.
7. **E…** The expression for the resistance of a resistor is given as $R = \frac{\rho L}{A}$. So, computing in turn, we find $R_1 = \frac{\rho L}{\pi r^2}$; $R_2 = \frac{\rho\left(\frac{L}{2}\right)}{\pi\left(\frac{r}{2}\right)^2} = 2\frac{\rho L}{\pi r^2}$; $R_3 = \frac{\rho\left(\frac{L}{4}\right)}{\pi\left(\frac{r}{2}\right)^2} = \frac{\rho L}{\pi r^2}$. Hence, $R_1 = R_3 < R_2$.
8. **A…** Copernicus published the heliocentric theory in 1512 while Galileo did a lot of work related to this theory about a century later. Isaac Newton started producing work in the 1660's while Maxwell's contributions to physics had to wait until the 1860's.
9. **B…** Since the conventional current in the circuit is directed to the right through the resistor, the electrons are flowing in the opposite direction (to the left). The electric field in the interior of the resistor would be in the direction of conventional current and hence points to the right.
10. **C…** By Newton's Second Law, in order to accelerate an object, there must be an imbalance in the forces. To accelerate an object upward, a force must exist on the object that exceeds the gravitational force acting on it. Hence, the required force is $F > W$.
11. **C…** From the information, we start by finding the acceleration as $a = \frac{F_{net}}{m} = \frac{12.0}{3.0} = 4.0\frac{m}{s^2}$. Using constant acceleration kinematics, we then have $v = v_0 + at \ \rightarrow v = 0 + (4)(5) = 20\frac{m}{s}$.
12. **B…** Kinetic energy is computed as $KE = \frac{1}{2}mv^2 = \frac{1}{2}(3.0)(20)^2 = 600\ J$.

13. **A…** The ideal mechanical advantage for an inclined plane is found as the length of the hypotenuse divided by the height. Hence, in this situation, we find $IMA = \frac{h}{y} = \frac{5.0}{3.0} = 1.67$.
14. **E…** From the equation sheet, we find the units for these quantities. Doing this gives $\sqrt{\frac{\frac{Nm^2}{kg^2}}{\frac{Nm^2}{C^2}}} = \sqrt{\frac{C^2}{kg^2}} = \frac{C}{kg}$. In other words, this has units of charge divided by mass.
15. **B…** Since all EM waves travel at the speed of light, we have $v = f\lambda \rightarrow \lambda = \frac{v}{f} = \frac{3.0\times10^8}{100\times10^6} = 3.0\ m$
16. **C…** From the first quarter rotation, we determine the angular acceleration as $\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2 \rightarrow \frac{\pi}{2} = 0 + \frac{1}{2}\alpha(1)^2 \rightarrow \alpha = \pi\frac{rad}{s^2}$. And so, for one full revolution, we have $\omega^2 = \omega_0^2 + 2\alpha\Delta\theta \rightarrow \omega^2 = 0^2 + 2(\pi)(2\pi) = (2\pi)^2$. Hence, $\omega = (2\pi)\frac{rad}{s}$.
17. **A…** This is a basic statement of Kepler's First Law.
18. **A…** By definition, average velocity is displacement divided by time. Hence, these quantities must be directed the same way.
19. **D…** Using the ideal gas equation in the form $PV = Nk_BT$, we compute $(1.0\ atm)(V) = (1.20\times10^{24})(1.38\times10^{-23})(27+273) = 4968\ Nm$. So, we need to convert the pressure as $1.0\ atm = 1.01\times10^5 Pa$. Hence, $V = \frac{4968}{1.01\times10^5} = 0.049\ m^3$.
20. **E…** From the original locations, we can balance the torques about the center of the plank to find $\tau_{net} = 0 \rightarrow (M_1)g(5) - (M_2)g(4) = 0 \rightarrow M_2 = \frac{5}{4}M_1$ where the distance of the mass M_2 to the rotation axis is $4.0\ m$. So, by moving the masses, we have the following torque condition: $\tau_{net} = (M_1)g(3) - (M_2)g(2)$. Replacing the mass $M_2 = \frac{5}{4}M_1$ into the new expression gives $\tau_{net} = (M_1)g(3) - \left(\frac{5}{4}M_1\right)g(2) = \frac{1}{2}Mg > 0$. As we assumed counterclockwise torques about the center are positive, the net torque being positive means that the right side will rise and the left side will fall. Since there is a torque imbalance, this motion occurs with a non-zero angular acceleration!
21. **B…** The minimum speed after launch for a projectile is when it reaches its apex (highest point) when the y-component of the projectile's velocity is $0\frac{m}{s}$. From constant acceleration kinematics, we find $v_y = v_{0y} + a_y t \rightarrow 0 = v_{0y} + (-10)(1.94) \rightarrow v_{0y} = 19.4\frac{m}{s}$. At the highest point, the total velocity of the object is the x-component of the velocity (which is constant). Making a right triangle using the initial velocity components gives the angle above the horizontal at launch to be $\tan\theta = \frac{v_y}{v_x} \rightarrow \theta = \tan^{-1}\left(\frac{19.4}{15.0}\right) = 52.3^\circ$.
22. **E…** In order to balance the reaction, we write ${}^{40}_{19}K + {}^{0}_{-1}e^- \rightarrow {}^{A}_{Z}X + {}^{0}_{0}\nu_e$. This means that we have $40 + 0 = A + 0 \rightarrow A = 40$. Further, $19 + (-1) = Z + 0 \rightarrow Z = 18$. By having $Z = 18$, this means that the element is different from Potassium as that has 19 protons. In other words, from the choices provided, we see that ${}^{A}_{Z}X = {}^{40}_{18}Ar$.
23. **C…** Buoyant force is computed as the "weight of the *fluid displaced.*" The balloons have the same size and therefore displace the same amount of air. In other words, the buoyant forces are the same! The difference between the balloons would be seen on release when the helium balloon rises and the xenon balloon falls.
24. **B…** For the proton to move with constant velocity, the net force on it must be zero. Since the proton moves at a right angle to the magnetic field, there is a magnetic force on the proton. By the right-hand rule, with the velocity up the plane of the page and the field into the place, the magnetic force is directed to the left. In order to cancel this force, the electric force acting on the proton must be directed to the right. By $\vec{F} = q\vec{E}$, the field and force are in the same direction for a positive charge. The field is directed to the right.

25. **A…** The force on the charged particle is computed as $\vec{F} = q\vec{E}$. The electric field between the plates of a capacitor can be found from $E = \frac{\Delta V}{d} = \frac{24.0\ V}{0.05\ m} = 480 \frac{V}{m} = 480 \frac{N}{C}$. So, we find the charge between the plates as $q = \frac{F}{E} = \frac{1.00}{480} = 0.00208\ C = 2.08\ mC$.
26. **C…** By adding the momenta of the masses together, we have the total momentum of the center of mass of the system. That is, $m_1\vec{v}_1 + m_2\vec{v}_2 = (m_1 + m_2)\vec{v}_{cm} \;\; \rightarrow (10)(8) + (5)(-7) = (10+5)v_{cm} \;\; \rightarrow 45 = 15\ v_{cm} \rightarrow \;\; v_{cm} = 3.00 \frac{m}{s}$.
27. **D…** For the initial situation, the third lowest frequency standing wave produced by the tube would be the fifth harmonic. Tubes closed at one end only have odd harmonics. This means that we have $f = \frac{5v}{4L}$. Since there are only odd harmonics, the next harmonic for the tube would be the seventh which has frequency $f_{new} = \frac{7v}{4L} = \frac{7}{5}\left(\frac{5v}{4L}\right) = \frac{7}{5}f$.
28. **D…** It was recently announced that gravitational waves have been detected!
29. **E…** The lens shown would be converging because of its shape. With the incident ray coming from the right side, the light will refract through the focus on the opposite side of the lens. This refracted ray is shown in the figure.

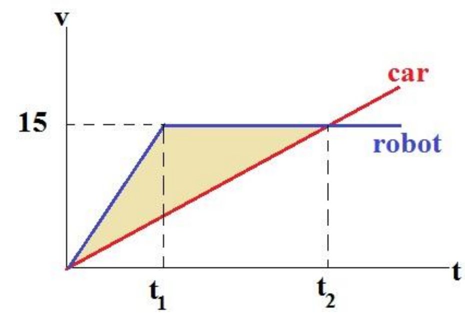


30. **A…** In order to melt a material, the property desired is the latent heat of fusion.
31. **E…** By removing bulb #2, the current for this branch becomes zero Amps meaning that the effective resistance of the circuit has risen. By increasing the effective resistance of the circuit means that the total current in the circuit will decrease. Since bulb #1 always receives the total current in the circuit, it now has a smaller potential difference from Ohm's Law $V = RI$ as the resistance of bulb #1 is unchanged. By Kirchhoff's Loop Rule, if the battery stays the same (which it did) and there is less potential difference across bulb #1, then there is more potential difference in the rest of the circuit (from Q to X)!
32. **D…** Since the mass is in simple harmonic motion, the angle from the vertical upon first release would be fairly small ($< 15^\circ$). When the mass swings through its lowest location, the acceleration of the mass would be straight up to the pivot of the pendulum. This means that $T > W$ to have more upward force compared to downward force. To check on the size of the net force, let us assume that it is equal to the gravitational force and determine the angle at which the mass is released. In other words, $F = W = \frac{mv^2}{L} = mg \;\rightarrow mv^2 = mgL$ where L is the length of the pendulum. From mechanical energy conservation during the fall of the mass to the lowest point from the highest, we write $\Delta KE + \Delta PE = 0 \rightarrow \left(\frac{1}{2}mv^2 - 0\right) + mg\big(-L(1-\cos\theta)\big) = 0$ where θ is the maximum angle that the string makes with the vertical. Using our substitution, we have $\frac{1}{2}mgL - mg\big(L(1-\cos\theta)\big) = 0 \;\rightarrow \cos\theta = \frac{1}{2} \;\rightarrow \theta = 60^\circ$. In other words, since we are nowhere near that initial angle, $F < W$ and $F < W < T$.
33. **B…** The electric potential is computed as $V = \frac{kQ}{r}$ for a point charge. As a result, at the point P, we have $V_p = \frac{kQ}{a} + \frac{kQ}{a} + \frac{k(-2Q)}{\sqrt{2}a} = \left(\frac{k}{a}\right)\left(2Q - \sqrt{2}Q\right) = \left(2 - \sqrt{2}\right)\left(\frac{kQ}{a}\right) > 0$ As for the field, we need to vector add. By the symmetry, the fields from the positive charges are directed at a 45° upward from the left. In other words, it is in the direction opposite to that from the negative charge. The total field from the positive charges comes to $\sqrt{\left(\frac{kQ}{a^2}\right)^2 + \left(\frac{kQ}{a^2}\right)^2} = \sqrt{2}\frac{kQ}{a^2}$. The field from the negative charge is $\frac{k(2Q)}{\left(\sqrt{2}a\right)^2} = \frac{kQ}{a^2}$. Since the field from the negative charge has a smaller magnitude that the fields from the positive charges, the resultant field points up and to the left.
34. **C…** Object 1 must be catching up to object 2 from behind because 1) the instantaneous momentum of neither object ever reached $0\ kg\frac{m}{s}$ and 2) object 1 loses momentum while object 2 gains momentum.

Because object 2 is in front of object 1 with $m_1 v_1 = m_2 v_2$ after collision then $v_2 \geq v_1$. This means that $m_2 \leq m_1$. In the limiting case of $m_2 = m_1$, then answers (A) and (D) would be true and (E) would be false. Answer B is incorrect from Newton's Third Law.

35. **A…** Iridescence has to do with the angle at which one is looking at an object and that the color of the object appears to change with it such as what happens with a peacock!

36. **B… METHOD #1:** One approach to the problem is to graph the velocity of each racer as a function of time. This is shown in the figure. The robot leads by its maximum amount when the speeds of the objects are the same. This is indicated at time t_2 whereas time t_1 indicates when the robot reaches its maximum speed. From the figure, we can find the change in position of each object with the area under the curve. This means that the distance that the robot leads the car is equal to the beige-colored triangle in the graph. All that is needed is to find the times of interest. This is done as follows:



$v_{robot} = v_0 + a_{robot} t_1 \rightarrow \ t_1 = \frac{v_{robot}}{a_{robot}} = \frac{15.0}{5.60} = 1.76\ s$ and

$v_{robot} = v_0 + a_{car} t_2 \rightarrow \ t_2 = \frac{v_{robot}}{a_{car}} = \frac{15.0}{5.60} = 2.68\ s.$

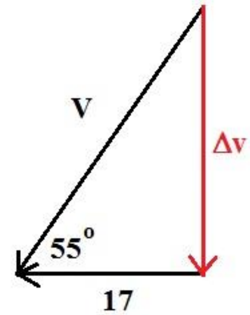
The area of the triangle is found as $A = \frac{1}{2}bh = \frac{1}{2}(t_2 - t_1)v_{robot} = \frac{1}{2}(2.68 - 1.76)(15) = 6.9\ m.$

METHOD #2: Alternatively, we can approach the problem from an algebraic point of view. In order to determine when the robot leads by the greatest distance, we need to find where the objects are when they have the same speed! In other words, it takes the car $v_{robot} = v_0 + a_{car} t \rightarrow \ t = \frac{v_{robot}}{a_{car}} = \frac{15.0}{5.60} = 2.68\ s$. By looking at constant acceleration kinematics for the car, we have its position as $x_c = x_{0c} + v_0 t + \frac{1}{2}a_{car}t^2 \ \rightarrow x_c = 0 + 0 + \frac{1}{2}(5.60)(2.68)^2 = 20.1\ m$. The motion for the robot occurs in two stages as it accelerates at $8.50\frac{m}{s^2}$ for some time and then travels at a constant rate thereafter. The robot reaches its maximum speed after $v_{robot} = v_0 + a_{robot} t_{robot} \rightarrow \ t_{robot} = \frac{v_{robot}}{a_{robot}} = \frac{15.0}{5.60} = 1.76\ s$. So, we compute the position of the robot after $2.68\ s$ as $\Delta x_{0\ to\ 1.76} + \Delta x_{1.76\ to\ 2.68}$. For the first part, we write $\Delta x_{0\ to\ 1.76} = v_0 t + \frac{1}{2}a_{robot}t^2 = 0 + \frac{1}{2}(8.50)(1.76)^2 = 13.2\ m$ and $\Delta x_{1.76\ to\ 2.68} = v_0 t + \frac{1}{2}a_{robot}t^2 = (15)(2.68 - 1.76) + 0 = 13.8\ m$. Hence, the robot is at a position of $13.2 + 13.8 = 27.0\ m$… a full $6.9\ m$ ahead of the car.

37. **E…** From the figure, we see that the string length from the oscillator to the pulley went from being one full wavelength on the left to being two full wavelengths on the right. This means that the wavelength is now ½ as large with the mass submerged. Since the oscillator is not changing the frequency of vibration, this means that the wave speed for the string is now ½ as large from $v = f\lambda$. The wavespeed on a string is determined as $v = \sqrt{T/\mu}$ which means to cut the speed in half resulted from a tension now ¼ as large.

38. **D…** From the free body diagram of the mass hanging on the string in the figure on the left, we find $F_{net} = Ma \rightarrow T - Mg = 0 \ \rightarrow T = 80\ N$. Since we determined in the previous question that the tension is now $20\ N$with the mass submerged. This means that there is a buoyant force of $60\ N$ acting on the mass from the water. So, $B = \rho_w g V_{dis} \ \rightarrow 60 = (1000)(10)V_{dis} \ \rightarrow V_{dis} = 0.006\ m^3$ where V_{dis} is the volume of displaced water (which is the same as the volume of the mass). Since the mass is a cube, $L^3 = 0.006\ m^3 \ \rightarrow \ L = 0.182\ m.$

39. A… METHOD #1: By definition, $\langle \vec{a} \rangle = \frac{\Delta \vec{v}}{\Delta t}$. Call the final speed of the object to be V and so we can write $\vec{v}_i = -17\,\hat{x} + 0\,\hat{y}$ indicating it is moving to the left at the start and then $\vec{v}_f = -V\cos 55^\circ\ \hat{x} - V\sin 55^\circ\ \hat{y}$. Also, we have $\langle \vec{a} \rangle = 0\,\hat{x} - 9.8\,\hat{y}$. And so, by looking at the x-component, we see $a_x = \frac{v_{fx} - v_{ix}}{T} \rightarrow 0 = \frac{(-V\cos 55^\circ) - (-17)}{T} \rightarrow$
$V = \frac{17}{\cos 55^\circ} = 29.6\frac{m}{s}$



METHOD #2: One can construct a vector picture representing the velocities as shown $\vec{V} = \vec{v}_i + \overrightarrow{\Delta v}$. Noting that the resultant change in velocity is straight downward (direction of acceleration), we see from the construction that $V = \frac{17}{\cos 55^\circ} = 29.6\frac{m}{s}$.

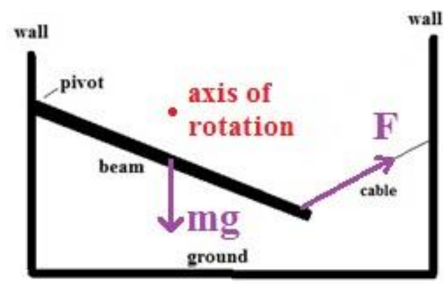
40. D… From the previous answer, we now consider the y-component of the acceleration to find the time. That is, we have $a_y = \frac{v_{fy} - v_{iy}}{T} \rightarrow -9.8 = \frac{(-V\sin 55^\circ) - (0)}{T} \rightarrow T = \frac{\frac{17}{\cos 55^\circ}\sin 55^\circ}{9.8} = \frac{17\tan 55^\circ}{9.8} = 2.48\ s$.

41. D… METHOD #1: Let's find things using kinematics. In the vertical direction, we write $v_y^2 = v_{0y}^2 + 2a_y\Delta y \rightarrow v_y^2 = (15\sin 30^\circ)^2 + 2(-10)(-10) \rightarrow v_y = -16.0\frac{m}{s}$. The x-component of the velocity is a constant $v_x = 15\cos 30^\circ = 13.0\frac{m}{s}$. Consequently, upon landing, the angle made by the object with the horizontal is computed as $\tan\theta = \frac{v_y}{v_x} \rightarrow \theta = \tan^{-1}\left(-\frac{16}{13}\right) = -50.9^\circ$

METHOD #2: Using mechanical energy conservation, we can find the speed of the object when it reaches the ground as $\Delta KE + \Delta PE = 0 \rightarrow \left(\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2\right) + mg\Delta y = 0 \rightarrow v_f^2 = v_0^2 - 2g\Delta y$ Hence, $v_f^2 = (15)^2 - 2(10)(-10) \rightarrow v_f = 20.6\frac{m}{s}$. Since the x-component of the velocity is $v_x = 15\cos 30^\circ = 13.0\frac{m}{s}$, we can find the angle below the horizontal as $\cos\theta = \frac{v_x}{v} \rightarrow \theta = \cos^{-1}\left(\frac{13}{20.6}\right) = 50.9^\circ$.

42. B… Using the lens equation, we have $\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \rightarrow \frac{1}{18} = \frac{1}{21} + \frac{1}{q} \rightarrow q = 126\ cm$. The magnification is found as $M = -\frac{q}{p} = -\frac{126}{21} = -6$. As the magnification is negative, this makes the image real and inverted. Since $|M| > 1$, the image is also larger than the object.

43. C… As the object is in static equilibrium, the sum of forces and the sum of torques must be zero. The force from the cable is upward and rightward. Because the gravitational force is downward, the pivot must be providing a force to the left in order to cancel the rightward force from the cable. As for the vertical component, by choosing an axis of rotation through the direction of the gravitational force at the vertical location of the pivot, the only non-zero torques are from the cable and the vertical component of the pivot force. As the torque from the cable would be oriented counterclockwise from this axis of rotation, the vertical force at the pivot needs to provide a clockwise torque. This is possible only if that vertical component is upward.



44. E… As the objects move in circular paths, it is because of the magnetic force which has a magnitude of qvB. Taking a ratio of the forces, we find $\frac{F_{He}}{F_p} = \frac{q_{He}v_{He}B}{q_p\ v_p\ B} \rightarrow 1 = (2)\left(\frac{v_{He}}{v_p}\right)(1) \rightarrow \left(\frac{v_{He}}{v_p}\right) = \frac{1}{2}$.

45. D… The kinetic energy of the electrons emitted range from $0\,J$ up to $\frac{1}{2}mv^2 = \frac{1}{2}(9.1 \times 10^{-31})(4.85 \times 10^5)^2 = 1.07 \times 10^{-19}\,J = 0.67\,eV$. The energy of the incoming photons is determined to be $E = \frac{hc}{\lambda} = \frac{(4.14\times 10^{-15})(3.0\times 10^8)}{250\times 10^{-9}} = 4.97\ eV$. The work function is determined by taking the difference between the maximum kinetic energy and the energy of the incoming photon, meaning $\phi = 4.97 - 0.67 = 4.30\ eV$.

46. A… The escape speed from a planet is found using mechanical energy conservation. That is, $\Delta KE + \Delta PE = 0 \rightarrow \left(0 - \frac{1}{2}mv_{esc}^2\right) + \left(0 - \left(-\frac{GmM}{R}\right)\right) = 0 \rightarrow v_{esc} = \sqrt{\frac{2GM}{R}}$. The mass of a planet would be computed as $M = \rho V = \rho\left(\frac{4}{3}\pi R^3\right)$. With this substitution, we have $v_{esc} = \sqrt{\frac{2G\rho\left(\frac{4}{3}\pi R^3\right)}{R}} = R\sqrt{\frac{8}{3}\rho G\pi}$. This means that $\frac{v_X}{v_y} = \frac{R_X}{R_Y} = \frac{2}{1}$.

47. C… Lenz's Law is required to answer this question. The magnetic field associated with the long wire is into the page to the right of the wire and out of the page to the left of the wire. As the loop on the right is moved away, there are weaker field lines penetrating into the loop. As a result, there is an induced current oriented to try to replace the missing field lines. This means that the current in the right loop is oriented clockwise to put field lines into the plane in the interior of the loop. Likewise, on the left side of the long wire, there are again weaker field lines coming out of the plane of the loop. Here, the induction would be for a current oriented counterclockwise to have additional field lines out of the plane through the interior of the loop.

48. B… The heat associated with the adiabatic process is zero Joules (as that is what it means to be reversibly adiabatic). For isobaric processes, the heat is $Q_p = nc_p\Delta T$ and for isovolumic processes, the heat is $Q_v = nc_v\Delta T$. Also, we need the ideal gas equation to determine what happens to the temperature. For (B), the temperature doubles resulting in $Q_B = n\left(\frac{5}{2}R\right)(2T - T) = \frac{5}{2}nRT$, for (C), we have $Q_C = n\left(\frac{3}{2}R\right)(2T - T) = \frac{3}{2}nRT$, and for (E) we compute $Q_E = n\left(\frac{5}{2}R\right)\left(\frac{T}{2} - T\right) = -\frac{5}{4}nRT$. Lastly, because there is no internal energy change for an isothermal process, $Q = W$ for this process. For the isobar in (B) there is a doubling in the internal energy with more negative work done than for the isotherm meaning that $Q_B > Q_E$ from $\Delta U = Q + W$.

49. A… Because the spaceship pilot is in one location, she has a single resting clock. This means that the time she records to cross the platform will be a proper time. From the pilot's perspective, the platform is length contracted to be of length $L = \frac{L_p}{\gamma} = \sqrt{1 - \left(\frac{v}{c}\right)^2}\ L_p = \sqrt{1 - \left(\frac{1.8}{3}\right)^2}\ (500) = 400\ m$. So, her clock will read a time of $\Delta t = \frac{L}{v} = \frac{400}{1.80\times10^8} = 2.22\mu s$

50. E… We will use mechanical energy conservation to approach this problem, $\Delta KE + \Delta PE = 0 \rightarrow \left(\frac{1}{2}I\omega^2 - 0\right) + (Mg\Delta y) = 0$. To find the moment of inertia about the pivot, we need the parallel axis theorem to obtain $I = \frac{1}{12}ML^2 + md^2$ where $d = \frac{L}{6}$ (the distance between the center of the mass and the pivot) leading to $I = \frac{1}{12}ML^2 + m\left(\frac{L}{6}\right)^2 = \frac{1}{9}\ ML^2$. Also, the center of mass will have $\Delta y = -\frac{L}{6}$ when the stick is horizontal. Upon substitution, we obtain $\left(\frac{1}{2}I\omega^2 - 0\right) + (Mg\Delta y) = 0 \rightarrow \frac{1}{2}\frac{1}{9}ML^2\omega^2 - Mg\frac{L}{6} = 0 \rightarrow \frac{1}{3}\ L\omega^2 - g = 0 \rightarrow \omega = \sqrt{\frac{3g}{L}}$. Finally, the speed of the center of mass will be computed as $v = \omega r$ with $r = \frac{L}{6}$ leading to $v = \sqrt{\frac{3g}{L}}\frac{L}{6} = \sqrt{\frac{3gL}{36}} = \frac{1}{\sqrt{12}}\sqrt{gL}$