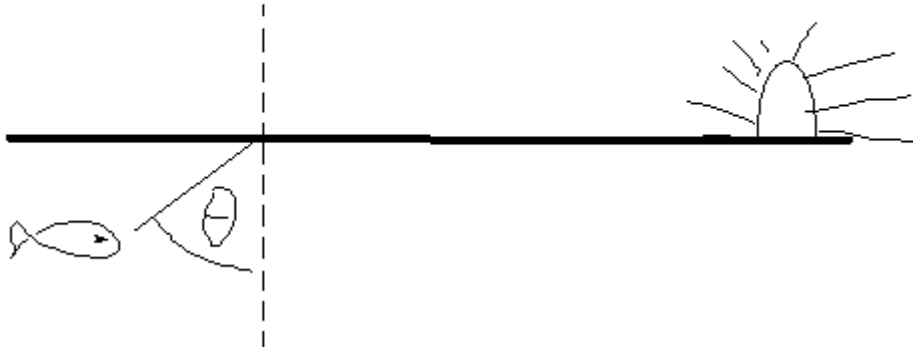


YOUR NAME	STUDENT NUMBER

1.	This is to identify the exam version you have - IMPORTANT Mark the A
2.	This is to identify the exam version you have - IMPORTANT Mark the B
3.	A 120 volt outlet is protected by a 10 amp circuit breaker. What is the maximum number of 60 watt light bulbs that can be connected in parallel to the outlet before setting off the circuit breaker? a. 2 b. 8 c. 10 d. 14 e. 20
4.	Radio waves differ from light waves in empty space because they a. Travel slower than light waves. b. Travel faster than light waves. c. Have a higher frequency and longer wavelength than light. d. Have a shorter wavelength and lower frequency than light. e. Have a longer wavelength and lower frequency than light.

5.

At what incident angle θ does a fish in the ocean see the sunset? (The index of refraction for water is $n = 1.333$.)

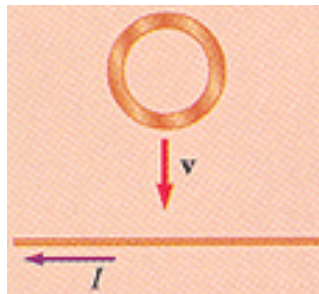


- a. 90°
- b. 0.75 radians
- c. 49°
- d. 41°
- e. The sunset is not visible to the fish.

6.

The figure shows a circular loop of wire being dropped toward a wire carrying a constant current to the left. The direction of the induced current in the loop of wire is which of the following?

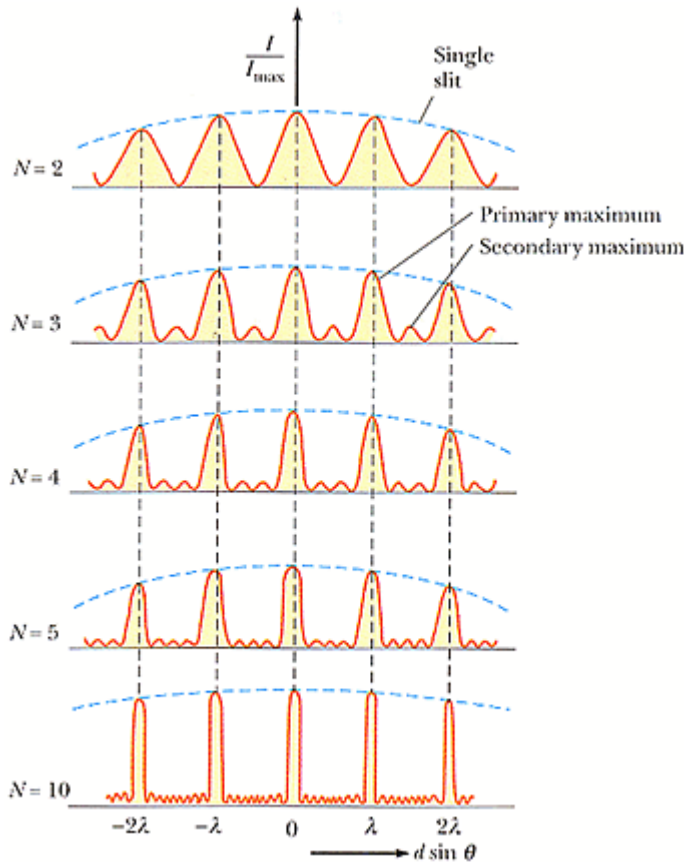
- a. clockwise
- b. zero
- c. impossible to determine
- d. counterclockwise



7.

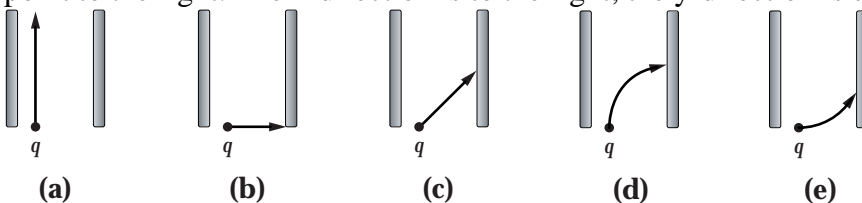
You observe an interference pattern like the one shown in the figure for three slits. If you then cover up the center slit so that no light gets through, the interference pattern that you will observe will be most like which of the following?

- the original three slit pattern but with every other maximum missing
- the original three slit pattern but with every third maximum missing
- the two slit pattern shown in the figure but with half the distance between maxima
- the two slit pattern shown in the figure but with every other maximum missing
- the two slit pattern shown in the figure



8.

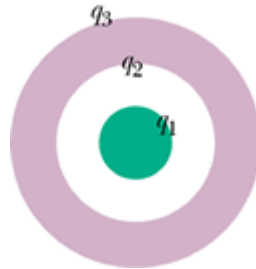
A positively charged particle is moving in the $+y$ -direction when it enters a region with a uniform electric field pointing in the $+x$ -direction. Which of the diagrams below shows its path while it is in the region where the electric field exists. The region with the field is the region between the plates bounding each figure. The field lines always point to the right. The x -direction is to the right; the y -direction is up.



9.

A **conducting** spherical shell (below) is concentric with a solid **conducting** sphere. Initially, each conductor carries zero net charge. A charge of $+2Q$ is placed on the **outer** sphere. After equilibrium is achieved, the charges on the surface of the solid sphere, q_1 , the inner surface of the spherical shell, q_2 , and the outer surface of the spherical shell, q_3 , are which of the following?

- A) $q_1 = -2Q, q_2 = +2Q, q_3 = 0$
- B) $q_1 = 0, q_2 = 0, q_3 = +2Q$
- C) $q_1 = 0, q_2 = +2Q, q_3 = 0$
- D) $q_1 = +2Q, q_2 = -2Q, q_3 = +2Q$
- E) $q_1 = 0, q_2 = -2Q, q_3 = +2Q$

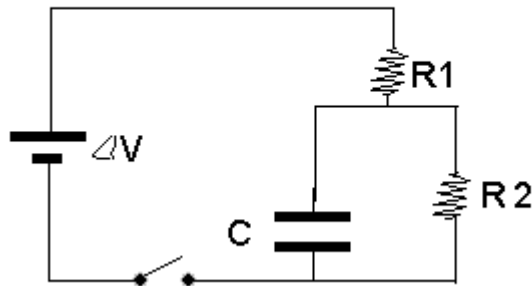


10.

$R_1 = 1 \text{ k}\Omega$
 $R_2 = 1 \text{ k}\Omega$
Capacitance = $10 \text{ }\mu\text{F}$
Battery voltage = 5 V

We close the switch, and immediately after this the voltage drop across R_2 is:

- a. 1.0 V
- b. 2.0 V
- c. 5.0 V
- d. 2.5 V
- e. zero



11.

$R_1 = 1\text{ k}\Omega$

$R_2 = 1\text{ k}\Omega$

Capacitance = $10\text{ }\mu\text{F}$

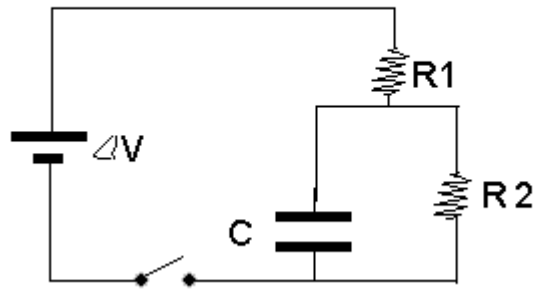
Battery voltage = 5 V

We close the switch, and

after we waited very long ...

the voltage drop across R_2 is:

- a. 1.0 V
- b. 2.0 V
- c. 5.0 V
- d. 2.5 V
- e. zero



12.

$R_1 = 1\text{ k}\Omega$

$R_2 = 1\text{ k}\Omega$

Capacitance = $10\text{ }\mu\text{F}$

Inductance $L = 2\text{ H}$

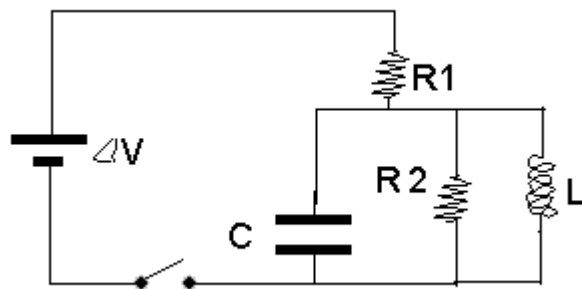
Battery voltage = 5 V

We close the switch, and

after we waited very long ...

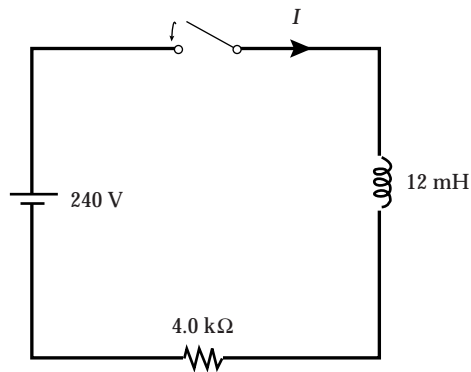
the voltage drop across R_2 is:

- a. 1.0 V
- b. 2.0 V
- c. 5.0 V
- d. 2.5 V
- e. zero



13.

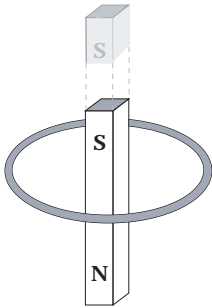
The switch in the figure is closed at $t = 0$ when the current I is zero. When $I = 15 \text{ mA}$, what is the potential difference across the inductor?



- a. 240 V
- b. 60 V
- c. 0
- d. 180 V
- e. 190 V

14.

A bar magnet is dropped from above and falls through the loop of wire shown below. The north pole of the bar magnet points downward towards the page as it falls. Which statement is correct?



- a. The current in the loop always flows in a clockwise direction.
- b. The current in the loop always flows in a counterclockwise direction.
- c. The current in the loop flows first in a clockwise, then in a counterclockwise direction.
- d. The current in the loop flows first in a counterclockwise, then in a clockwise direction.
- e. No current flows in the loop because both ends of the magnet move through the loop.

15.

A 3 cm high virtual image of a 2cm high object is seen through a lens. The object is 15 cm's away from the lens. What is the focal length of the lens?

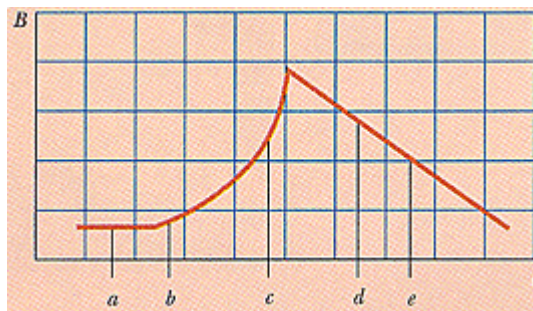
- a. 22.5 cm
- b. 45 cm
- c. -25 cm
- d. 3.5 cm
- e. -33 cm

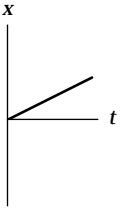
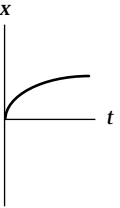
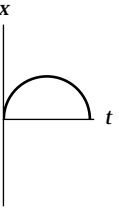
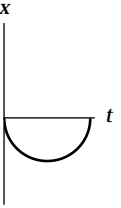
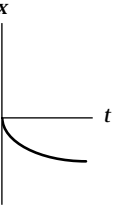
16.

The figure shows a graphical representation of the field magnitude versus time for a magnetic field that passes through a fixed loop and is oriented perpendicular to the plane of the loop. The magnitude of the magnetic field at any time is uniform over the area of the loop.

Rank the magnitudes of the emf = ΔV generated in the loop at the five instants indicated, from largest to smallest. (Use only the symbols $>$ or $=$, for example $a > b > c = d > e$.)

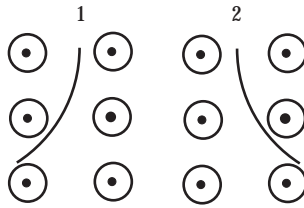
- a. $d > c > e > b > a$
- b. $a > b > c > d = e$
- c. $c = d > e = b > a$
- d. $c > d = e > b > a$
- e. $b = c = d = e > a$



<p>17.</p>	<p>The electric <u>potential energy</u> of an <u>electron</u> is monotonously increasing in the direction of the $+x$ axis. From this we can conclude that</p> <ul style="list-style-type: none"> a) ΔV is monotonously increasing in the $+x$-direction and E is constant and in the $+x$-direction b) ΔV is monotonously decreasing in the $+x$-direction and E is constant and in the $+x$-direction c) ΔV is monotonously increasing in the $+x$-direction and E is constant and in the $-x$-direction d) ΔV is monotonously decreasing in the $+x$-direction and E is constant and in the $-x$-direction e) ΔV is constant and E is zero
<p>18.</p>	<p>A particle (charge = $+2.0$ mC) moving in a region where only electric forces act on it has a kinetic energy of 5.0 J at point A. The particle subsequently passes through point B which has an electric potential of $+1.5$ kV relative to point A. Determine the kinetic energy of the particle as it moves through point B.</p> <ul style="list-style-type: none"> a. 3.0 J b. 2.0 J c. 5.0 J d. 8.0 J e. 10.0 J
<p>19.</p>	<p>A negatively charged particle is moving in the $+x$-direction when it enters a region with a uniform electric field pointing in the $+x$-direction. Which graph gives its position as a function of time correctly? (Its initial position is $x = 0$ at $t = 0$.)</p> <div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;">  <p>(a)</p> </div> <div style="text-align: center;">  <p>(b)</p> </div> <div style="text-align: center;">  <p>(c)</p> </div> <div style="text-align: center;">  <p>(d)</p> </div> <div style="text-align: center;">  <p>(e)</p> </div> </div>

20.

A magnetic field is directed out of the page. Two charged particles enter from the top and take the paths shown in the figure. Which statement is correct?



- a. Particle 1 has a positive charge and particle 2 has a negative charge.
- b. Both particles are positively charged.
- c. Both particles are negatively charged.
- d. Particle one has a negative charge and particle 2 has a positive charge.
- e. The direction of the paths depends on the magnitude of the velocity, not on the sign of the charge.

Kinematics	$\mathbf{v} = \mathbf{v}_0 + \mathbf{a} \cdot t$ $\mathbf{x} = \mathbf{x}_0 + \mathbf{v}_0 \cdot t + \frac{1}{2} \mathbf{a} \cdot t^2$ $\mathbf{v}^2 = \mathbf{v}_0^2 + 2\mathbf{a} \cdot (\mathbf{x} - \mathbf{x}_0)$ $\bar{v} = (\mathbf{v} + \mathbf{v}_0) / 2$
Newton's Law	$\mathbf{F} = m \cdot \mathbf{a}$ $\mathbf{F}_{\text{gravity}} = m \cdot \mathbf{g} \quad \mathbf{g} = 9.80 \text{ m/s}^2$
Conservation of Energy	$KE_1 + U_1 + W_{\text{in/out}} = KE_2 + U_2$
Energy	Kinetik (linear): $KE_{\text{lin}} = \frac{1}{2} m v^2$ Potential (gravity): $U_g = m g y$
Work	$W = \mathbf{F} \cdot \mathbf{d} = F d \cos\theta$
Power (electrical)	$P = W/t = E/t$ $P = I \Delta V = I^2 R = (\Delta V)^2 / R$
Coulomb force	$\mathbf{F} = k_e q_1 q_2 / r^2 \hat{r} \quad k_e = 1/4\pi\epsilon_0$
Electric field	$\mathbf{E} = \mathbf{F}/q = k_e \int_{\text{volume}} \frac{dq}{r^2} \hat{r} = -\nabla V$ $\mathbf{E} = k_e q \hat{r} / r^2$ for a point charge
Electric flux	$\Phi_E = \int_{\text{surface}} \vec{E} d\vec{A}$
Gauss Law	$\Phi_E = \int_{\text{closed surface}} \vec{E} d\vec{A} = q_{\text{inside}}/\epsilon_0 = 4\pi k_e \cdot q_{\text{inside}}$
Potential energy	$\Delta U = U_B - U_A = -q \int_A^B \vec{E} d\vec{s} = q \Delta V$
Potential	$\Delta V = \Delta U / q = - \int_A^B \vec{E} d\vec{s} \quad (= k_e q/r \text{ point charge})$
Capacitance	$C = Q/\Delta V \quad [= \epsilon_0 A/d \quad \text{parallel plate C}]$ $C_{\text{eq}} = C_1 + C_2 + C_3 + \dots$ [parallel combination] $1/C_{\text{eq}} = 1/C_1 + 1/C_2 + 1/C_3 + \dots$ [series combination] $U = Q^2/2C = \frac{1}{2} Q \Delta V = \frac{1}{2} C (\Delta V)^2$ [energy stored in C]
Charging/discharging of Capacitor	$q(t) = Q \cdot (1 - e^{-t/RC})$ $I(t) = (\Delta V/R) \cdot e^{-t/RC}$ $q(t) = Q \cdot e^{-t/RC}$ $I(t) = -(\Delta V/R) \cdot e^{-t/RC}$
Ohm's Law	$R = \Delta V/I = \rho \cdot l/A \quad [\rho = \text{resistivity} = 1/\sigma]$
Resistivity / Resistance	$\rho = m_e / (n q^2 \tau) [\tau = \text{scattering time}]$ $\rho = \rho_0 [1 + \alpha(T - T_0)]$ [temperature dependence] $1/R_{\text{eq}} = 1/R_1 + 1/R_2 + 1/R_3 + \dots$ [parallel] $R_{\text{eq}} = R_1 + R_2 + R_3 + \dots$ [series]

Magnetic force	$\mathbf{F}_B = q \cdot \mathbf{v} \times \mathbf{B}$ $\mathbf{F}_B = I \cdot \mathbf{L} \times \mathbf{B}$ [force on straight conductor] $d\mathbf{F}_B = I \cdot d\mathbf{s} \times \mathbf{B}$ [force on conductor segment] $F_B/L = (\mu_0 I_1 I_2) / (2\pi a)$ [force between 2 parallel wires]
Cyclotron motion [circular motion of a charge in a magnetic field]	$r = (mv) / (qB)$ [radius] $\omega = (qB) / m$ [frequency]
Magnetic Field by a current Ampere's Law	$d\mathbf{B} = \mu_0/4\pi \cdot (I d\mathbf{s} \times \hat{r}) / r^2$ [Biot-Savart Law] $B = (\mu_0 I) / 2\pi a$ [long straight wire] $\oint_{\text{closed loop}} \vec{B} d\vec{s} = \mu_0 I$
Magnetic Flux	$\Phi_B = \int_{\text{surface}} \vec{B} d\vec{A}$
Faraday's Law of Induction	$\text{emf} = (\Delta V) - N \cdot (d\Phi_B / dt)$
Lenz' Law	the polarity of the induced emf is such that it wants to act 'against' the cause.
Inductor	$\text{emf} = (\Delta V) - L \cdot dI/dt$
LR circuit	$I = \Delta V/R \cdot (1 - e^{-t/\tau})$ 'switch on' $I = \Delta V/R \cdot e^{-t/\tau}$ 'switch off' $\tau = L/R$
Speed of a wave	$v = f \cdot \lambda$ (light in vacuum: $c = f \cdot \lambda$)
Index of refraction	$n = c/v = \lambda_o/\lambda$
Snell's Law	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
Total reflection	$\sin\theta_c = n_2 / n_1$
Mirror and lens Equations	$1/p + 1/q = 1/f$ $m = h' / h = -q / p$ $f = R/2$ (mirror)
Diffraction Double slit or grating	$d \cdot \sin\theta_{\text{bright}} = m \cdot \lambda$ ($m = 0, \forall 1, \forall 2, \dots$) $d \cdot \sin\theta_{\text{dark}} = (m + 1/2) \cdot \lambda$ ($m = 0, \forall 1, \forall 2, \dots$)
Electron mass	$m_e = 9 \times 10^{-31}$ kg
Proton mass	$m_p = 2 \times 10^{-27}$ kg
Elementary charge	$e = 1.6 \times 10^{-19}$ C [electron: -e ; proton: +e]
Coulomb constant	$k_e = 9 \times 10^9$ Nm ² /C ²
Permittivity of free space	$\epsilon_0 = 9 \times 10^{-12}$ C ² /Nm ² $k_e = 1 / (4\pi\epsilon_0)$
Permeability of free space	$\mu_0 = 4\pi \cdot 10^{-7}$ Tm /A
Speed of light	$c = 3 \times 10^8$ m/s