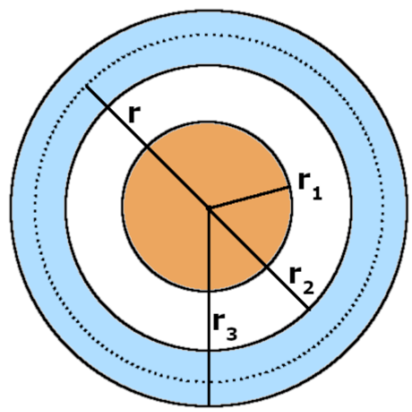
Physics 207 – Comprehensive Exam

Sections (519-524; 525-530) – April 29, 2022

1) [6] A solid insulating sphere of radius r_1 and total charge $+Q$ is surrounded by a thick conducting spherical shell of inner radius r_2 and outer radius r_3 and total charge $-Q$. What is the value of the electric field within the conducting shell at a radius r? ($r_2 < r < r_3$)

A) $\vec{E} = \frac{+kQ}{r^2}\hat{r}$ [3]
B) $\vec{E} = \frac{-kQ}{r^2}\hat{r}$
C) $\vec{E} = \frac{+kQ}{r_1^2}\hat{r}$
D) $\vec{E} = \frac{-kQ}{r_1^2}\hat{r}$
E) $\vec{E} = \frac{+kQ}{r_2^2}\hat{r}$
F) $\vec{E} = \frac{-kQ}{r_2^2}\hat{r}$
G) $\vec{E} = \frac{+kQ}{r_3^2}\hat{r}$
H) $\vec{E} = 0$ [6]



2) [6] A solid conducting sphere of radius r_1 and charge $+q$ lies centered at the origin. A second solid sphere of insulator has radius r_2 and charge $-2q$ and is located at the position $x = d$. Find the position on the x-axis where the electric potential is zero.

A) $x = 0$
B) $x = d$
C) $x = \frac{d}{2}$
D) $x = \frac{d}{3}$ [6]
E) $x = \frac{2d}{3}$ [2]
F) $x = d - (r_1 + r_2)$
G) $x = d - (r_1 - r_2)$
H) $x = \frac{d}{(r_1 - r_2)}$

3) [7] In an experiment, three initially uncharged identical capacitors are connected to a battery in a series fashion and each capacitor is found to have charge Qs. In a second experiment the same uncharged capacitors are connected to a battery in a parallel fashion and each capacitor is found to have charge Qp. What is the ratio Qs/Qp ?

A) 1/3 [7] B) 1 C) 1/9 [2] D) 9 E) 3 [4] F) 1/6 G) 6

4) [7] A curved line of uniform total charge $+Q$ and radius r extends for three quarters of a circle centered at the origin as shown in the diagram below. What is the total force acting on a test particle of charge $-q$ positioned at the origin?

A) $\vec{F} = \frac{kqQ}{r^2}\hat{\imath} + \frac{kqQ}{r^2}\hat{\jmath}$

B) $\vec{F} = \frac{kqQ}{r^2}\hat{\imath} - \frac{kqQ}{r^2}\hat{\jmath}$

C) $\vec{F} = -\frac{kqQ}{r^2}\hat{\imath} + \frac{kqQ}{r^2}\hat{\jmath}$

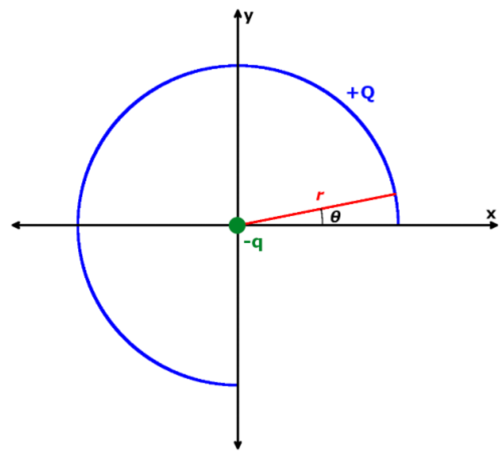
D) $\vec{F} = -\frac{kqQ}{r^2}\hat{\imath} - \frac{kqQ}{r^2}\hat{\jmath}$

E) $\vec{F} = \frac{2kqQ}{3\pi r^2}\hat{\imath} + \frac{2kqQ}{3\pi r^2}\hat{\jmath}$

F) $\vec{F} = \frac{2kqQ}{3\pi r^2}\hat{\imath} - \frac{2kqQ}{3\pi r^2}\hat{\jmath}$ [4]

G) $\vec{F} = -\frac{2kqQ}{3\pi r^2}\hat{\imath} + \frac{2kqQ}{3\pi r^2}\hat{\jmath}$ [7]

H) $\vec{F} = -\frac{2kqQ}{3\pi r^2}\hat{\imath} - \frac{2kqQ}{3\pi r^2}\hat{\jmath}$

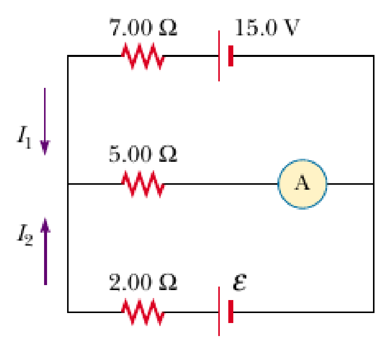


5) [7] Three identical resistors, each having resistance R, are connected in parallel to an ideal battery having potential difference V. At what rate does the battery supply energy to the resistor network?

A) $\frac{V^2}{R}$ B) $\frac{3V^2}{R}$ [7] C) $\frac{9V^2}{R}$ D) $\frac{V^2}{3R}$ [3] E) $\frac{V^2}{9R}$

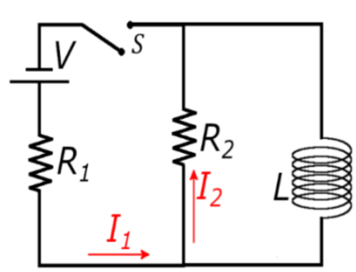
6) [7] The ammeter shown in Figure reads 2.00 A. Find Є.

A) 10 V
B) 12.6 V [7]
C) 13.1 V
D) 14 V
E) 15.3 V
F) 17 V



7) [7] In the circuit in the diagram below, the switch has been closed for a very long time. At $t = 0$, the switch is moved to the opened position as shown. Determine the two currents in the circuit at time $t = 0.16s$. The components have values: $V = 150\ V$, $R_1 = 10\ \Omega$, $R_2 = 20\ \Omega$ and $L = 2\ H$.

A) $I_1 = 15\ A,\quad I_2 = 0$
B) $I_1 = 0,\quad I_2 = 15\ A,$ [3]
C) $I_1 = 0,\quad I_2 = -15\ A$ [4]
D) $I_1 = 3\ A,\quad I_2 = 0$
E) $I_1 = 3\ A,\quad I_2 = 0$
F) $I_1 = 0,\quad I_2 = 3\ A$ [5]
G) $I_1 = 0,\quad I_2 = -3\ A$ [7]

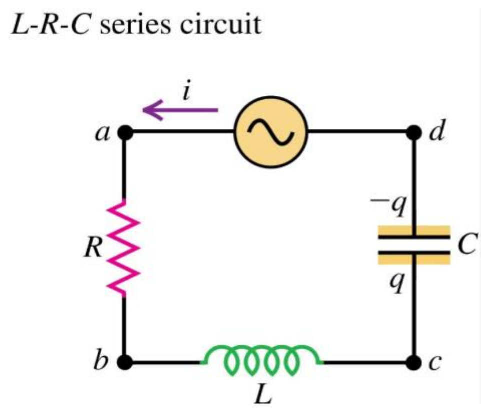


8) [6] A capacitor with a capacitance of C is charged by connecting it to a V volt battery. The capacitor is then disconnected from the battery and connected across an inductor with an inductance of L. At what time after the connection to the inductor has made that the charge on the capacitor decreased to half of its original value?

A) $t = \frac{\pi}{2}\sqrt{LC}$ [2]
B) $t = \frac{\pi}{3}\sqrt{LC}$ [6]
C) $t = \frac{\pi}{4}\sqrt{LC}$ [2]
D) $t = \frac{\pi}{2}/\sqrt{LC}$
E) $t = \frac{\pi}{3}/\sqrt{LC}$ [2]
F) $t = \frac{\pi}{4}/\sqrt{LC}$

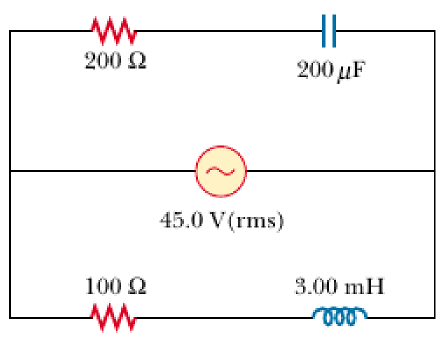
9) [7] An *L-R-C* series circuit as shown is operating at its resonant frequency. If the source is given by $\epsilon=\epsilon_0 \cos(\omega t)$, what is the average power dissipated over the resistance R?

A) $\frac{\epsilon_0^2}{2R}$ [7]
B) $\frac{\epsilon_0^2}{R}$ [4]
C) $\frac{2\epsilon_0^2}{R}$
D) $\frac{\epsilon_0^2}{4R}$
E) $\frac{4\epsilon_0^2}{R}$



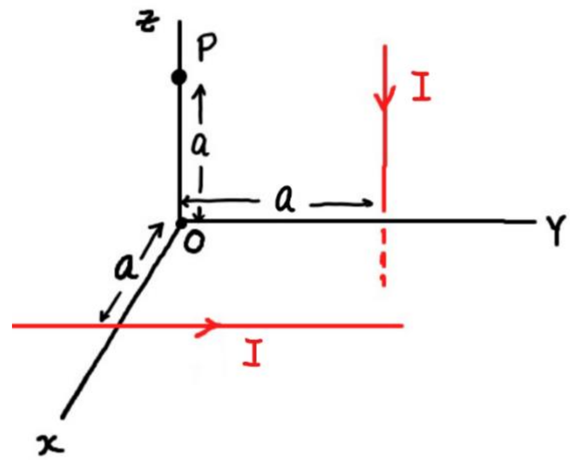
10) [7] Find the ratio $\frac{I_L}{I_S}$ where I_L is the rms current delivered by the power supply when the frequency is very large and I_S is the rms current delivered by the power supply when the frequency is very small.

A) 2 [4]
B) 3
C) 4
D) 1/2 [7]
E) 1/3
F) 1/4



11) [7] Two currents of magnitude I are on the x-y plane at x=a and on the y-z plane at y=a as shown. The total magnetic field produced by both currents at the the position P on the z-axis is

A) $\frac{\mu_0 I}{2\pi a}(\hat{\boldsymbol{i}} + \hat{\boldsymbol{k}})$
B) $\frac{\mu_0 I}{2\pi a}(\hat{\boldsymbol{i}} - \hat{\boldsymbol{k}})$
C) $\frac{\mu_0 I}{2\pi a}(-\hat{\boldsymbol{i}} + \hat{\boldsymbol{k}})$ [3]
D) $\frac{\mu_0 I}{2\pi a}(\frac{1}{2}\hat{\boldsymbol{i}} + \frac{1}{2}\hat{\boldsymbol{k}})$ [3]
E) $\frac{\mu_0 I}{2\pi a}(-\frac{1}{2}\hat{\boldsymbol{i}} + \frac{1}{2}\hat{\boldsymbol{k}})$ [7]
F) $\frac{\mu_0 I}{2\pi a}(\frac{1}{2}\hat{\boldsymbol{i}} - \frac{1}{2}\hat{\boldsymbol{k}})$
G) $\frac{\mu_0 I}{2\pi a}(-\frac{1}{2}\hat{\boldsymbol{i}} - \frac{1}{2}\hat{\boldsymbol{k}})$ [2]



12) [6] A particle with charge $-5.70\ \mathrm{nC}$ is moving in a uniform magnetic field $\vec{B} = -(1.26\ \mathrm{T})\hat{k}$. The magnetic force on the particle is measured to be $\vec{F} = -(3.40\times10^{-7}\ \mathrm{N})\hat{i} + (7.60\times10^{-7}\ \mathrm{N})\hat{j}$.

The x-component of the velocity of the particle must be

A) 0 m/s
B) 25 m/s
C) -25 m/s
D) 47 m/s [3]
E) -47 m/s [3]
F) 106 m/s [4]
G) -106 m/s [6]

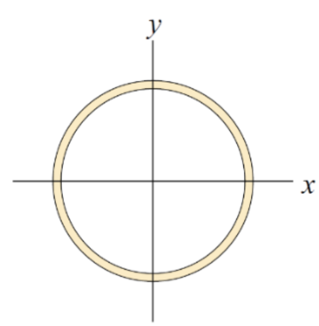
13) [7] A circular loop of wire lies in the x-y plane as shown. The loop is exposed to a uniform, time-varying magnetic field. Rank the following uniform magnetic field in order of the magnitude of emf that they produce in the loop at t=0, from the largest to the smallest

A) ABC
B) ACB
C) BCA [7]
D) BAC [3]
E) CAB [3]
F) CBA

$A.\ \mathbf{B} = \cos(3t)\hat{\mathbf{k}}$

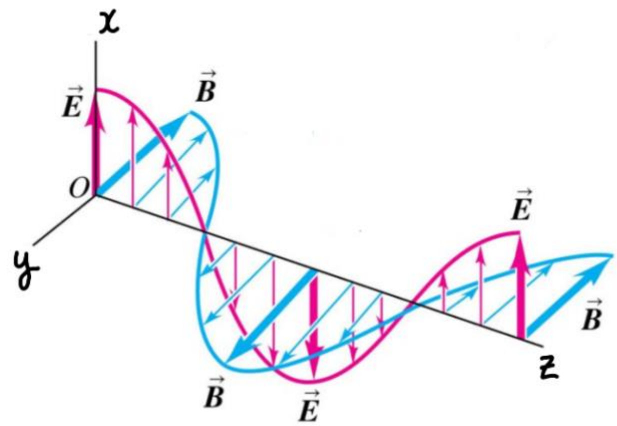
$B.\ \mathbf{B} = 2e^{-2t}\hat{\mathbf{k}}$

$C.\ \mathbf{B} = (4t^2 + 3t)\hat{\mathbf{k}}$



14) [6] An electromagnetic plane wave is propagating in free space as shown. A possible description of this wave is

A) **E**= $E_0\cos(kx-\omega t)$ **i** [3]
B) **E**= $-E_0\cos(ky-\omega t)$ **j**
C) **E**= $-E_0\cos(kz-\omega t)$ **k**
D) **B**= $B_0\cos(kx+\omega t)$ **k**
E) **B**= $-B_0\cos(ky+\omega t)$ **i**
F) **B**= $-B_0\cos(kz+\omega t)$ **j** [6]



15) [7] A radius *r* helium-neon laser shines directly, and exerted a force of *F,* on a mirror. The amplitude of the magnetic field in the laser light must be

A) $B_{max} = \sqrt{F\varepsilon_0/2\pi r^2}$
B) $B_{max} = \sqrt{2F\varepsilon_0/\pi r^2}$
C) $B_{max} = \sqrt{F\varepsilon_0/\pi r^2}$
D) $B_{max} = \sqrt{F\mu_0/\pi r^2}$ [7]
E) $B_{max} = -\sqrt{F\mu_0/\pi r^2}$ [3]
F) $B_{max} = \sqrt{2F\mu_0/\pi r^2}$ [3]
G) $B_{max} = -\sqrt{2F\mu_0/\pi r^2}$