DEPARTMENT OF PHYSICS

PHYCS 102

Final Exam

8:30 – 10:30

Question	Marks
MCQs	(/40)
Problem 1	(/15)
Problem 2	(/15)
Problem 3	(/15)
Problem 4	(/15)
Total	(/100)
Total	(/40)

Use BLOCK LETTERS:

*Full Name:*_______________________________

*Student ID #.:*______________________________

*Section :*_______________________________

Student Signature:_________________________

***Date*: June 15th 2006**

*** Use:** $\pi = 3.14$ Charge of an electron or a proton = 1.6×10^{-19}C,

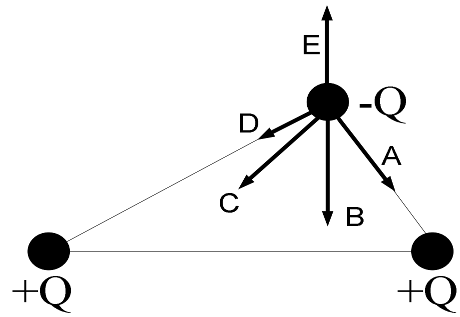
$m_e = 9.11\times10^{-31}$ kg, $m_p = 1.67\times10^{-27}$ kg

$k = 9\times10^{9}$ N.m^2/C^2, $\varepsilon_0 = 8.84\times10^{-12}$ C^2/N.m^2 $\mu_0 = 4\pi\times10^{-7}$ Wb/A.m

PART A: MCQs

*** Choose the correct answer.**
*** Each question carries the same weight (2 marks).**

1) Three point charges are placed at the corners of a triangle as shown. The correct direction of **the net electrostatic force** on the point charge -Q is:



a) A
b) B
c) C
d) D
e) E

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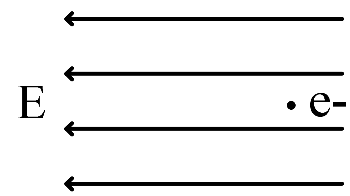
2) If an electron is released from rest in a uniform electric field directed to the left, as shown in the figure, then:



a) the electron will remain at rest.
b) the electron will move with constant speed to the right.
c) the electron will accelerate toward the left.
d) the electron will move with constant speed to the left.
e) the electron will accelerate toward the right.

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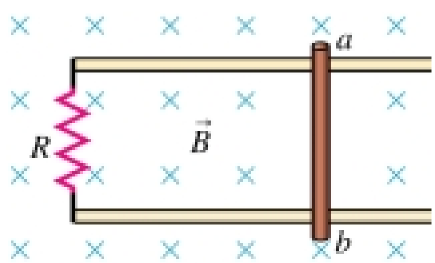
3) A 25-cm-long metal bar is pulled to the right at steady speed of 5 m/s perpendicular to a uniform 0.8 T magnetic field. The bar slides on parallel metal rails connected through a resistor R, as shown in the figure. The induced emf ε (in V) in the circuit is:



a) 4
b) 3
c) 2
d) 1
e) 0

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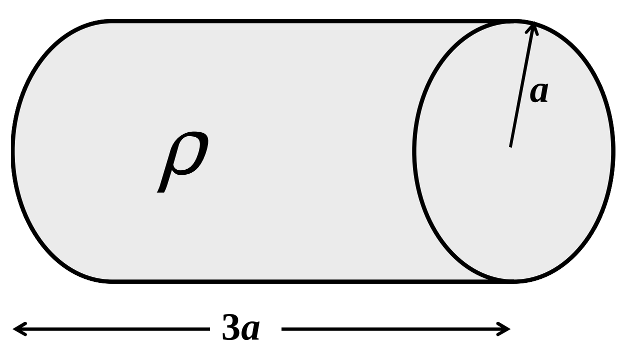
4) A material of resistivity ρ is shaped as a solid cylinder of radius *a* and length 3*a*, as shown in the figure. The electric resistance between its ends is:



a) $\dfrac{\pi\rho}{3}$

b) $\dfrac{3\rho}{\pi a}$

c) $\dfrac{\pi\rho}{3a}$

d) $\dfrac{\pi\rho}{3}a$

e) $\dfrac{\pi\rho}{3}a^2$

5) If the self-inductance of a coil made of 100 turns is L = 80 mH, then the magnetic flux through it when a current I = 10 mA passes through the coil is:

a) 8 μWb
b) 80μWb
c) 8000 Wb
d) 12.5 Wb
e) 800 μWb

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6) The velocity (in m/s) of an electron that passes without any deflection, through perpendicular electric and magnetic fields (E = 4 kV/m and B = 4 mT) is:

a) 1×10^6
b) 3×10^6
c) 16×10^6
d) 4×10^6
e) 8×10^6

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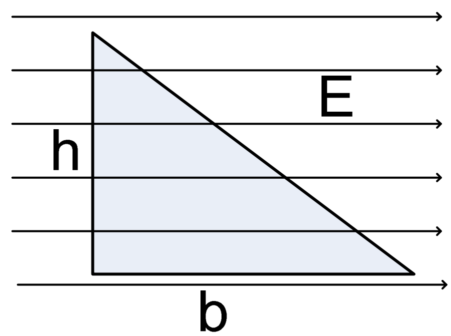
7) A triangular loop of base b and height h is placed in a region of uniform electric field directed along the x-axis, as shown in the figure. The net electric flux through the triangle is:



a) $\frac{1}{2} bhE$
b) bhE
c) zero
d) $\frac{E}{2bh}$
e) $\frac{2E}{bh}$

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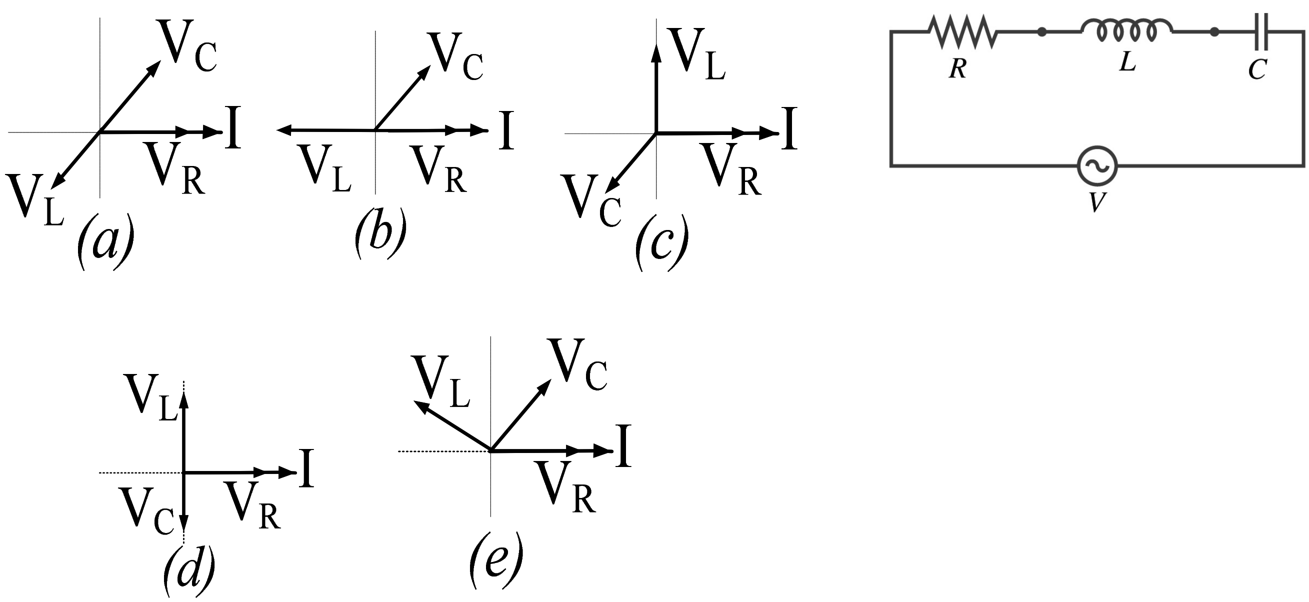
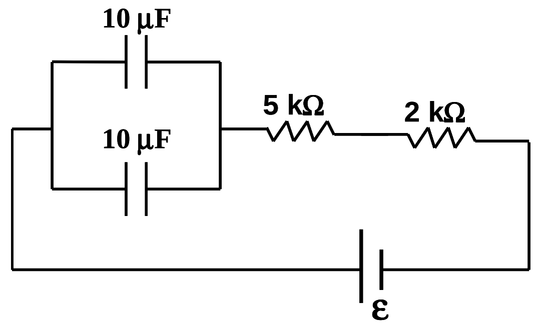
8) Consider the L-R-C circuit with an AC source, as shown in the figure, which of the following phasor diagrams is correct?



9) Calculate the time constant for the circuit shown in the figure:



a) 140 μs
b) 1.4 s
c) 140 ms
d) 14 s
e) 14 ms

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10) The correct relation for charge Q and current I is:

a) I = Q
b) I = Q t
c) $I = \int Q\, dt$
d) $Q = \frac{dI}{dt}$
e) $Q = \int I\, dt$

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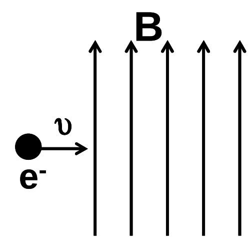
11) An electron enters a magnetic field as shown in the figure. The direction of initial deflection of the electron is:



a) out of the page.
b) into the plane of the page.
c) opposite to the direction of B.
d) the same direction as B.
e) in the same direction as υ

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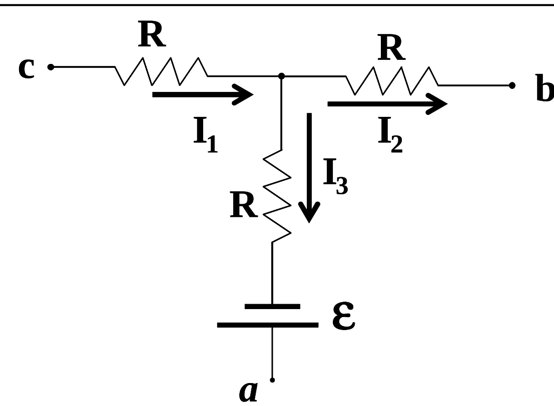
12) The figure shows a part of a circuit; the correct statement for the potential difference (V_b-V_a) is: :



a) $\varepsilon - I_3R - I_2R$
b) $-\varepsilon - I_3R - I_2R$
c) $-\varepsilon - I_3R + I_2R$
d) $-\varepsilon + I_3R - I_2R$
e) $\varepsilon + I_3R - I_2R$

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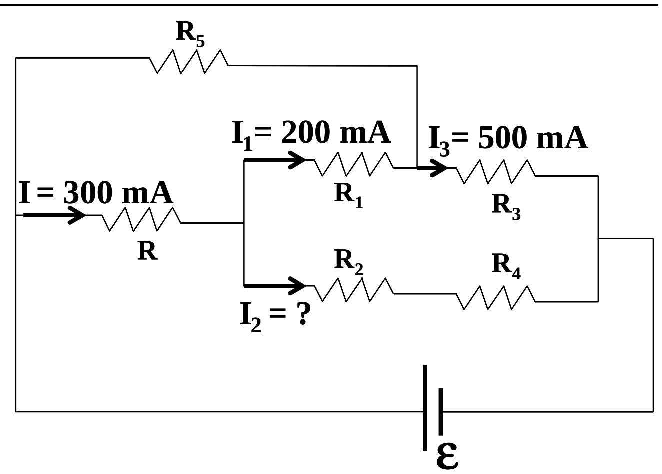
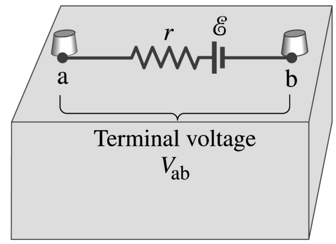
13) In the circuit shown the current I_2 equals:



a) 100 mA
b) 200 mA
c) 500 mA
d) 150 mA
e) 50 mA

14) A dry cell delivering 2A has a terminal voltage V_{ab} =1.41 V. If the emf ε = 1.59 V, the internal resistance (in Ω) of the cell is:



a) zero
b) 0.18
c) 0.71
d) 0.51
e) 0.09

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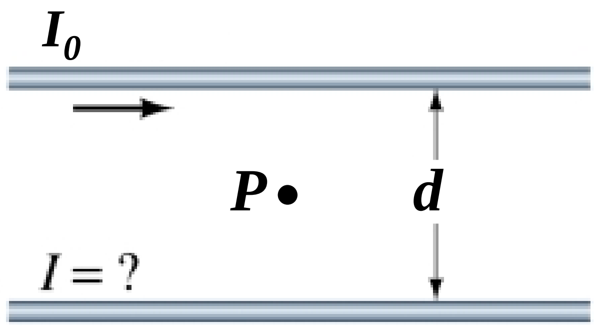
15) Two straight wires are arranged parallel to each other, as shown in the figure. If the net magnetic field at point P midway between the wires equals zero, then:



a) $I = I_0$ and flowing to the left.
b) $I = ½ I_0$ and flowing to the right.
c) $I = I_0$ and flowing to the right.
d) $I = 2I_0$ and flowing to the right.
e) $I = 2I_0$ and flowing to the left.

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16) A copper wire carries a current of 1 A at 20 °C. If the wire temperature coefficient of resistance α = 0.004 $°C^{-1}$, then the current (in A) in the wire when its temperature increases to 100 °C is: (Assume that the voltage supplied to the wire remains the same)

a) 0.76
b) 1.52
c) 2.27
d) 3.03
e) 3.79

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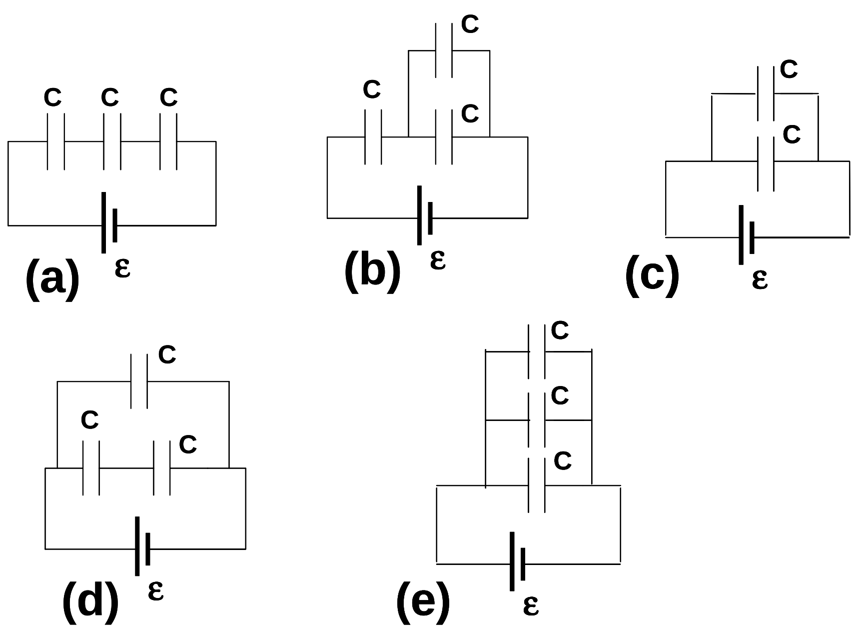
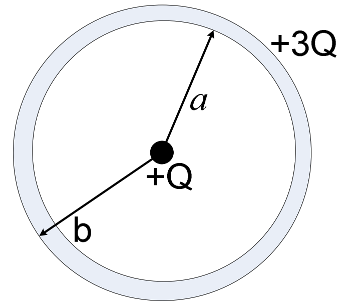
17) In the circuits shown all batteries have the same emf (ℰ) and all capacitors are the same. In which circuit is the total charge maximum?



18) A point charge +Q is placed inside a charged conducting spherical shell of radii *a* and b, as shown in the figure. If the charge on the outer surface of the conducting shell is +3Q then the net charge on the conducting shell is:

a) zero
b) -2Q
c) +3Q
d) +2Q
e) – Q



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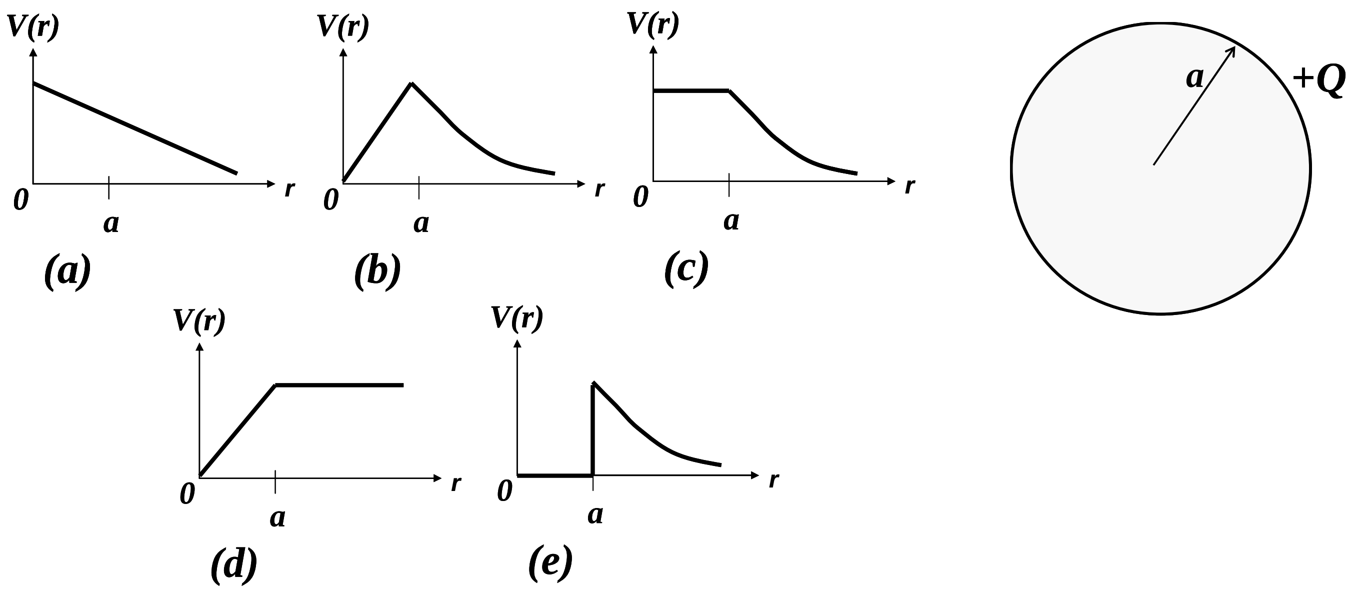
19) A charged conducting sphere of radius *a* carries a net charge +Q. The correct graph for the variation of electric potential with distance from the center of the sphere is:



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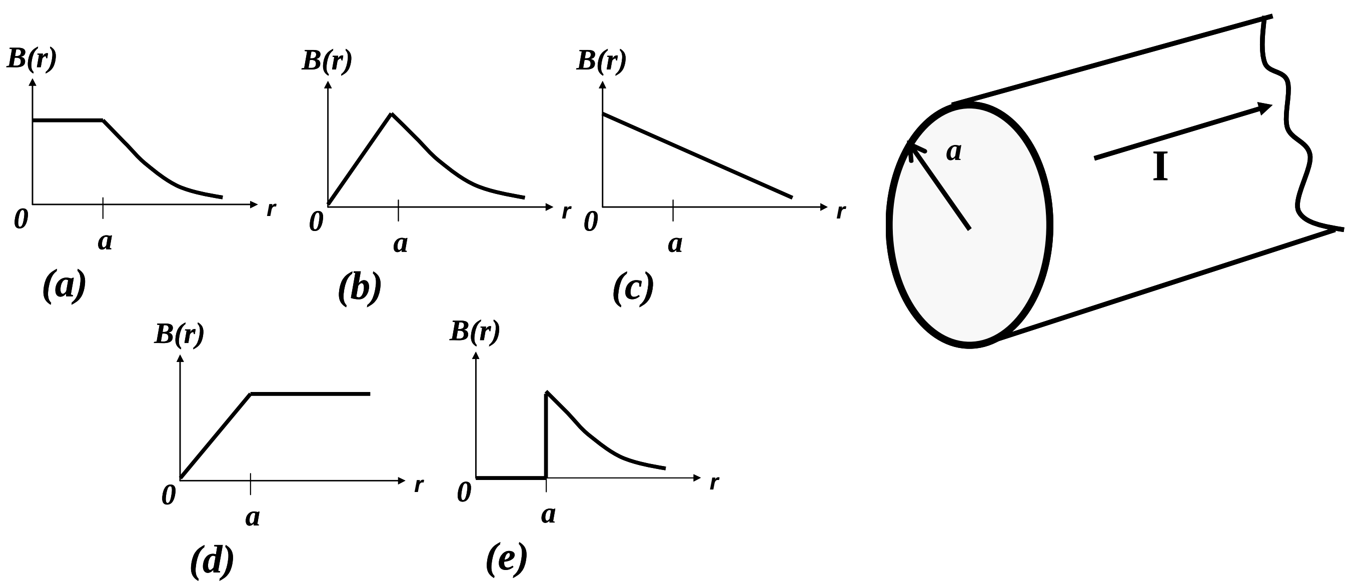
20) A long solid cylindrical conductor of radius *a* carries a current I uniformly distributed. The correct variation of the magnetic field inside and outside the conductor is:



Answers for multiple choices (MCQ) of final test

MCQ #	1	2	3	4
Ans	B	E	D	B

MCQ #	5	6	7	8
Ans	A	A	C	D

MCQ #	9	10	11	12	13
Ans	C	E	B	D	A

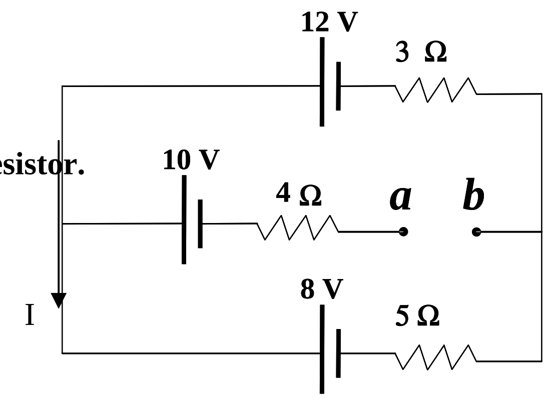
MCQ #	14	15	16	17
Ans	E	C	A	E

MCQ #	18	19	20
Ans	D	C	B

PART B: Problems: **Show all calculations.**

Problem # 1:

Consider the circuit shown in the figure.



[5 Marks]a) Find the current passing through the 5Ω resistor.

$\Sigma\varepsilon = \Sigma IR$,

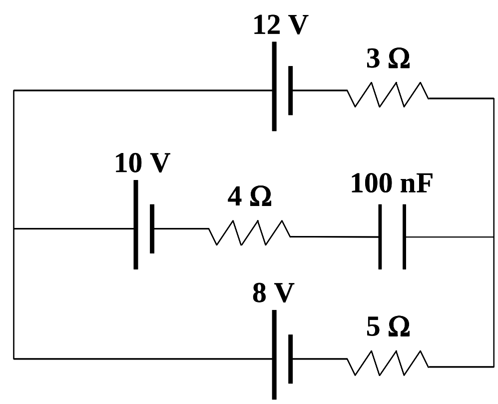
$12 - 8 = 3I + 5I$, $I = 0.5$ A

[5 Marks] a) Find the potential difference V_{ab}.

$V_{ab} = 12 - 10 - 0.5 \times 3 = 0.5$ V

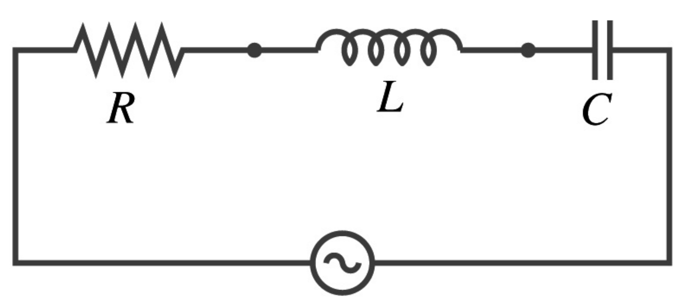
[5 Marks] c) If a capacitor with C = 100 nF is connected between point *a* and b as shown below, find the final charge on the capacitor after a long period of time.

$C = Q/V_{ab}$, $Q = (100 \times 10^{-9})(0.5) = 50$ nC



Problem # 2:

For the L-R-C series circuit shown in the figure, suppose R = 100 Ω, L = 200 mH, C = 10 µF, and V = 100 cos(1000 t), where time t in seconds.



V = 100 cos(1000 t)

[2 Marks] a) Find the inductive reactance X_L of the circuit.

$X_L = \omega L = 200\ \Omega$

where $\omega = 1000\ s^{-1}$.

[2 Marks] b) Find the capacitive reactance X_C of the circuit.

$X_c = 1/\omega C = 100\ \Omega$.

[3 Marks] c) Find the impedance Z of the circuit.

$Z = [\,R^2 + (X_L - X_c)^2\,]^{0.5} = 141.4\ \Omega$

[2 Marks] d) Find the phase angle ϕ.

$\phi = \tan^{-1}[(X_L - X_c)/R] = 45^o$

[2 Marks] e) Find the amplitude of the current passing in the circuit.

$I_m = V_m/Z = 100/141.4 = 0.707$ A

[2 Marks] f) Find the root mean square current I_{rms} passing in the circuit.

$I_{rms} = 0.707\ I_m = 0.5$ A

[2 Marks] g) Find the average power supplied to the circuit.

$P = (1/2) I_m V_m \cos\phi = (1/2)\, 0.707 \times 100 \times \cos 45 = 25$ W

Problem # 3:

A thin wire of length L with uniform charge density +λ is bent as shown in the figure.

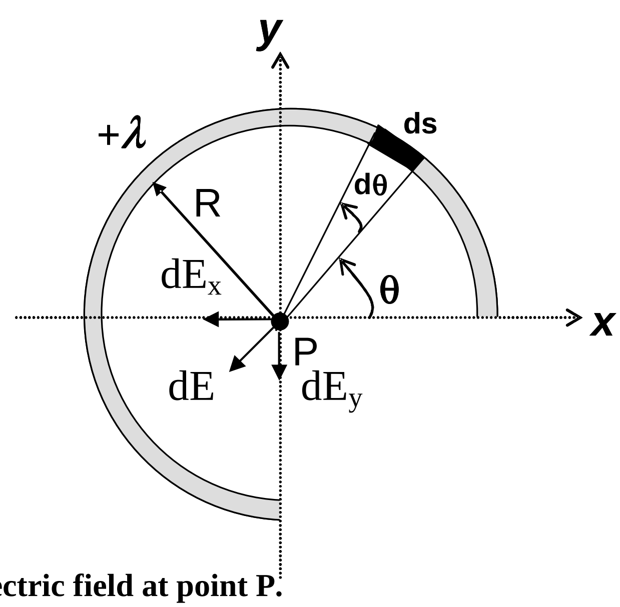
[10 Marks] a) Find the electric field components (E_x and E_y) at point P due to the charge distribution.

$dE_x = dE\cos\theta = -K(\lambda ds/R^2)\cos\theta$, $ds = R\,d\theta$

$$E_x = -(K\lambda/R)\int_0^{3\pi/2}\cos\theta\, d\theta = K\lambda/R$$

$dE_y = dE\sin\theta = -K(\lambda d\theta/R)\sin\theta$

$$E_y = -(K\lambda/R)\int_0^{3\pi/2}\sin\theta\, d\theta = -K\lambda/R$$



[2 Marks] b) Find the magnitude of the net electric field at point P.

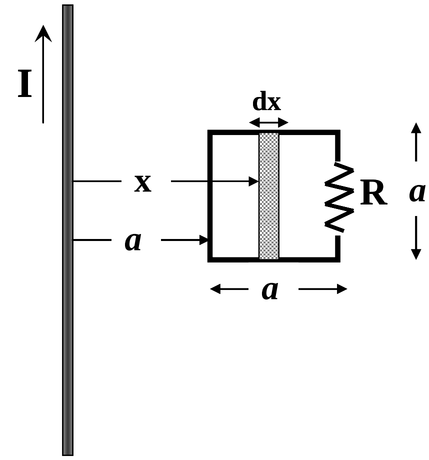
$E = [(K\lambda/R)^2 + (-K\lambda/R)^2]^{0.5} = \sqrt{2}\,K\lambda/R$

[3 Marks] c) If a positive point charge q with mass m is placed at point P, find the magnitude of its initial acceleration once it is set free to move.

$F = ma = qE$, $a = \sqrt{2}\,Kq\lambda/mR$

Problem # 4:

In the figure, a square loop of side *a* is placed at a distance *a* from a very long conducting thin wire carrying a varying current I.



[2 Marks] a) Find the magnitude and direction of the magnetic field produced by the wire at a distance x to the right.

$B = \mu_0 I / 2\pi x$, pointing into the page

[6 Marks] b) Show that the magnetic flux through the square loop is given as: $\Phi = \dfrac{\mu_0 I a}{2\pi} \ln(2)$

$$\phi = \int_s B\, dA \cos\theta = \int_a^{2a} (\mu_0\, I\, a / 2\pi)(dx / x),\ where\ dA = adx$$

$$\phi = (\mu_0\, I\, a / 2\pi) \ln 2.$$

c) If the side of the loop *a* = 10 cm and the current in the long wire varies with time as I = 2+10t, where t in seconds, then find:

[3 Marks] i) the induced emf ε in the loop.

$\varepsilon = -(d\Phi/dt) = -(\mu_0 a/2\pi) \ln 2\ (dI/dt) = -1.39\times10^{-7}$ V, where $dI/dt = 10$ A/s

[2 Marks] ii) the induced current in the loop if its resistance R = 0.1 Ω .

$I = \varepsilon / R = 1.39\ \mu A$

[2 Marks] iii) the direction of the induced current in the loop.

Counter clockwise