STUDENT NUMBER:

NAME:

SECTION NUMBER:

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KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS

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COURSE: PH102

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EXAM: PH102 FINAL EXAM - 002
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TEST CODE NUMBER: XXX

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INSTRUCTIONS:
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1. PRINT YOUR STUDENT NUMBER, NAME, AND SECTION NUMBER ON THE EXAM.

2. PRINT YOUR STUDENT NUMBER, SECTION NUMBER, AND YOUR NAME ON
   THE EXAM ANSWER FORM. PRINT THE TEST CODE NUMBER, OR CHECK
   IT IF IT HAS ALREADY BEEN PRINTED ON YOUR ANSWER FORM.

3. CODE YOUR STUDENT NUMBER AND SECTION NUMBER ON THE EXAM ANSWER
   FORM. CODE THE TEST CODE NUMBER, OR CHECK IT IF IT IS ALREADY
   CODED.

4. CODE YOUR ANSWERS ON THE EXAM ANSWER FORM. YOU MUST NOT GIVE
   MORE THAN ONE ANSWER PER QUESTION.

5. RETURN THE EXAM AND ANSWER FORM TO THE INSTRUCTOR WHEN YOU
   HAVE FINISHED.

Dear respected student,
To get the most benefit form this old exam, I suggest the following,
    (1)   Solve it without seeing the answers.
    (2)   Time yourself. A question should not take more than 6 minutes.
    (3)   Compare your answers with the answers provided at the end of this
    exam.
    (4)   If your answer is wrong, study why you did not get it right. If
    you cannot know your mistake, ask your friends or come to me.

****
QUESTION NO: 1
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      The capacitor in figure (1) is initially charged to 50 V and
then the switch is closed. What charge flows out of the
capacitor during the first minute after the switch was closed?

A.   1.4 mC.
B.   3.6 mC.
C.   4.8 mC.
D.   0.3 mC.
E.   1.7 mC.

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QUESTION NO: 2
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      Electrons are accelerated from rest through a potential
difference of 500 V. They are then deflected by a magnetic
field of 0.2 T that is perpendicular to their velocity. The
radius of the electrons trajectory is:

A.   2.4 milli-m.
B.   0.38 milli-m.
C.   1.6 milli-m.
D.   0.54 milli-m.
E.   0.15 milli-m.

****
QUESTION NO: 3
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      A parallel combination of two capacitors, C1 and C2
where C2=2*C1, is connected to a battery. If the charge
accumulated on C1 is 2.0*10**(-6) C and the total
energy stored in the combination is 12.0*10**(-9) Joule,
then the capacitance of C2 is:

A.   1.5*10**(-3) F.
B.   2.5*10**(-6) F.
C.   1.5*10**(-6) F.
D.   3.0*10**(-6) F.
E.   1.0*10**(-3) F.

****
QUESTION NO: 4
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        Consider a circular loop of wire within which the magnetic flux,
        Phi, is given as a function of time, t, as
                    Phi =   a*t**2 + b,
        where a and b are constants. If the induced emf is measured as
        48 V at t=3 s, what is the value of a?

        A.   - 4.0 V/s.
        B.   - 6.0 V/s.
        C.   - 2.1 V/s.
        D.   - 3.2 V/s.
        E.   - 8.0 V/s.

****
QUESTION NO: 5
****

        In figure (4), a loop of wire carrying a current, I, of 2.0 A
        is in the shape of a right triangle with two equal sides, each
        15 cm long. A 0.7 T uniform magnetic field is in the plane
        of the triangle and is perpendicular to the hypotenuse.
        The resultant magnetic force on the two equal sides is:

        A.   0.30 N, out of the page.
        B.   0.41 N, into the page.
        C.   0.41 N, out of the page.
        D.   Zero.
        E.   0.30 N, into the page.

****
QUESTION NO: 6
****

        Suppose that the identical currents I in figure (7) are all
        out of the page. The magnitude of the force per unit length
        on the wire at the origin is:
        [take I = 10.0 A, and a = 1.0*10**(-4) m.]

        A.   0.18   N/m.
        B.   0.17   N/m.
        C.   0.28   N/m.
        D.   0.30   N/m.
        E.   0.55   N/m.

****
QUESTION NO: 7
****

        If the electric potential in a certain region is given by:
              V(x,y,z) = -4*x*z - 5*y + 3*(z**2)   Volts,
        where x, y and z are in meters. What is the magnitude of
        the electric field at the point (+2,-1,-3)?

        A.   125 V/m.
        B.   25 V/m.
        C.   29 V/m.
        D.   35 V/m.
        E.   10 V/m.

****
QUESTION NO: 8
****

        Find the values of the currents in figure (3).

        A.   I1 = 2 A, I2 = 2 A, I3 = 4 A.
        B.   I1 = 2 A, I2 = 2 A, I3 = -4 A.
        C.   I1 = -2 A, I2 = -2 A, I3 = -4 A.
        D.   I1 = 2 A, I2 = -2 A, I3 = zero.
        E.   I1 = -2 A, I2 = 2 A, I3 = zero.

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QUESTION NO: 9
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        An electric device, which heats water by immersing a
        resistance wire in the water, generates 153 J of heat per
        second when an electric potential difference of 12 V is
        placed across its ends. What is the resistance of the
        heater wire?

        A.   0.58 Ohms
        B.   2.10 Ohms
        C.   0.94 Ohms
        D.   0.81 Ohms
        E.   0.48 Ohms

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QUESTION NO: 10
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A magnet is taken towards a metallic ring in such a way that
a constant current of 10**(-2) A is induced in it. The total
resistance of the ring is 0.25 Ohm. In 10 seconds, the flux
of the magnetic field through the ring changes by:

A.   2.5*10**(-3) Wb.
B.   2.5*10**(-6) Wb.
C.   2.5*10**(-2) Wb.
D.   2.5*10**(-9) Wb.
E.   2.5*10**(-1) Wb.

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QUESTION NO: 11
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Faraday's law states that an induced emf is proportional to:

A.   the rate of change of magnetic flux.
B.   the rate of change of magnetic field.
C.   the rate of change of electric flux.
D.   the rate of change of gravitational field.
E.   the rate of change of electric field.

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QUESTION NO: 12
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The linear density of a vibrating string is 1 g/m.
A transverse wave is propagating on the string and
is given by the equation:
        y(x,t) = 2.0*sin(x - 40*t),
where x and y are in meters and t is in seconds. What
is the tension in the string?

A.   5.2 N.
B.   0.9 N.
C.   2.1 N.
D.   1.9 N.
E.   1.6 N.

****
QUESTION NO: 13
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A solenoid is 3.0 m long and has a circumference of
$9.4*10**(-2)$ m. It carries a current of 12.0 A. The magnetic
field inside the solenoid is $25.0*10**(-3)$ T. The length
of the wire forming the solenoid is:

A.   410 m.
B.   900 m.
C.   233 m.
D.   467 m.
E.   245 m.

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QUESTION NO: 14
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3.00-kg of water at 100 degrees Celsius is converted to steam
at 100 degrees Celsius by boiling at one atmospheric pressure.
For one kg of water, the volume changes from an initial value
of $1.0*10**(-3)$ m**3 as a liquid to 1.671 m**3 as steam.
The work done by the water in this process is:

A. $3.01*10**5$ J.
B. $1.69*10**5$ J.
C. $5.07*10**5$ J.
D. $2.45*10**5$ J.
E. $1.23*10**5$ J.

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QUESTION NO: 15
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A stationary source emits a sound wave of frequency f.
If a man travels toward this stationary source with a
speed twice the speed of sound, he would observe the
emitted sound to have a frequency of:

A.   3*f.
B.   f.
C.   indefinite frequency.
D.   2*f.
E.   f/2.

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QUESTION NO: 16
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The mass of a hydrogen molecule is 3.3*10**(-27) kg. If
1.0*10**23 hydrogen molecules per second strike 2.0 cm**2
of wall at an angle of 55 degrees with the normal when
moving with a speed of 1.0*10**3 m/s, what pressure do
they exert on the wall?

A.   2.8*10**3 Pa.
B.   5.7*10**3 Pa.
C.   1.9*10**3 Pa.
D.   8.6*10**3 Pa.
E.   0.9*10**3 Pa.

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QUESTION NO: 17
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In figure (8), a hollow sphere, of radius r and carries a
negative charge -q, is put inside another hollow sphere, of
radius R and carries a positive charge Q. At a distance x from
the common center, such that r < x < R, the potential is:

A.   k*[(Q/R)-(q/r)].
B.   k*[(Q/R)+(q/x)].
C.   k*[(Q/x)-(q/R)].
D.   k*[(Q/R)+(q/r)].
E.   k*[(Q/R)-(q/x)].

****
QUESTION NO: 18
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In figure (2), if Vc-Vd=6.0 Volts, what is the emf of the
battery?

A.   9.61   Volts.
B.   18.2   Volts.
C.   13.9   Volts.
D.   10.8   Volts.
E.   11.7   Volts.

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QUESTION NO:    19
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A ball of charge -50 e lies at the center of a hollow spherical
metal shell that has a net charge of -100 e. What is the charge
on the outer surface of the shell?

A.   100 e.
B.   - 50 e.
C.   150 e.
D.   -100 e.
E.   -150 e.


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QUESTION NO:    20
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A conductor consists of a circular loop of radius R = 0.10 m
and two straight, long sections, as in Figure (6). The wire
lies in the plane of the paper (xy-plane) and carries a current
of I = 5.3 A. Determine the magnetic field, in Tesla, at the
center of the loop. (k is a unit vector in +z-direction)

A.   -5.8*10**(-5) k.
B.   5.8*10**(-5) k.
C.   -4.4*10**(-5) k.
D.   1.8*10**(-5) k.
E.   4.4*10**(-5) k.


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QUESTION NO:    21
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Two positive charges, q1 and q2, lie on the x-axis. The first
charge, q1 = 12.0*10**(-6) C, is at the origin, and the second
charge, q2 = 3.0*10**(-6) C, is at 3.0 m. Where must a
negative charge, q3, be placed on the x-axis such that
the resultant force on it is zero?

A.   3.0 m.
B.   - 1.0 m.
C.   2.0 m.
D.   - 1.5 m.
E.   1.0 m.

****
QUESTION NO: 22
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The current loop in figure (5) consists of one loop with two
semicircles of different radii. If the current in the circuit
is 19 A, a = 3.0 cm and b = 5.0 cm, then the magnetic dipole
moment of the current loop is:

A.   1.15 A*m**2, into the page.
B.   0.02 A*m**2, into the page.
C.   0.02 A*m**2, out of the page.
D.   0.10 A*m**2, out of the page.
E.   0.10 A*m**2, into the page.

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QUESTION NO: 23
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A magnetic field CANNOT:

A.   accelerate a charge.
B.   exert a force on a charge.
C.   change the momentum of a charge.
D.   exert a torque on a charged particle.
E.   change the kinetic energy of a charge.

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QUESTION NO: 24
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Which of the following statements are CORRECT:

1. Waves carry energy and momentum.
2. Mechanical waves need a medium to propagate.
3. Sound waves are transverse waves.
4. A Wave on a stretched string is a longitudinal wave.
5. For a tube closed at one end, only odd harmonics are present.

A.   2 and 4.
B.   1, 2 and 3.
C.   1 and 4.
D.   3 and 5.
E.   1, 2, and 5.

****
QUESTION NO: 25
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Which of the following statements are WRONG:

1. In order to achieve the lowest resistance from several
   resistors, they should be connected in parallel.
2. In order to achieve the lowest capacitance from several
   capacitors, they should be connected in parallel.
3. The resistance of a conductor does not depend on temperature.
4. A dielectric increases the capacitance of a capacitor.
5. The electric flux through a closed surface is always zero.

A.   1 and 4.
B.   1 and 3.
C.   2 and 4.
D.   1, 2 and 3.
E.   2, 3 and 5.

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QUESTION NO: 26   Not required for final 032
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An electric dipole, of electric charge $9.3*10^{(-12)}$ C and
distance $1.0*10^{(-3)}$ m, is in an electric field of strength
1100 N/C. What is the difference in potential energy
corresponding to dipole orientations parallel and
anti-parallel to the field?

A. $1.03*10^{(-11)}$ J.
B. $6.15*10^{(-15)}$ J.
C. $4.08*10^{(-13)}$ J.
D. $3.87*10^{(-11)}$ J.
E. $2.05*10^{(-11)}$ J.

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QUESTION NO: 27
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An electron is projected into a uniform magnetic field
B = (0.8 k) T. Find the magnitude of the magnetic force,
on the electron when the velocity is:
          v = (5.0*10**5 i + 3.0*10**5 j) m/sec.
(i, j and k are the unit vectors in the x, y and z directions,
respectively).

A.   ZERO.
B.   1.2*10**(-13) N.
C.   5.2*10**(-15) N.
D.   7.5*10**(-14) N.
E.   7.8*10**(-18) N.

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QUESTION NO: 28
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Which of the following statements are CORRECT:

1. Two objects are in thermal equilibrium if they have the same
     temperature.
2. In an isothermal process, the work done by an ideal gas is
     equal to the heat energy
3. In an adiabatic process, no heat enters or leaves the system.
4. The thermal efficiency of an ideal engine can be = 1.0.
5. For any process the change in entropy of a closed system < 0.

A.   4 and 5.
B.   1, 2 and 5.
C.   1, 2, and 3.
D.   1 and 4.
E.   3 and 5.

****
QUESTION NO: 29
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The sum of the currents entering a junction equals the sum
of the currents leaving that junction is a consequence of:

A.   Ampere's law
B.   conservation of charge
C.   Coulomb's law
D.   conservation of energy
E.   Newton's second law

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QUESTION NO: 30
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A long solid cylindrical conductor of radius R= 4.0 mm carries
a current I parallel to its axis. The current density in the
wire is 2*10**4 A/m**2. Determine the magnitude of the magnetic
field at a point that is 5.0 mm from the axis of the conductor.

A.   55   micro-T.
B.   12   micro-T.
C.   40   micro-T.
D.   17   micro-T.
E.   30   micro-T.
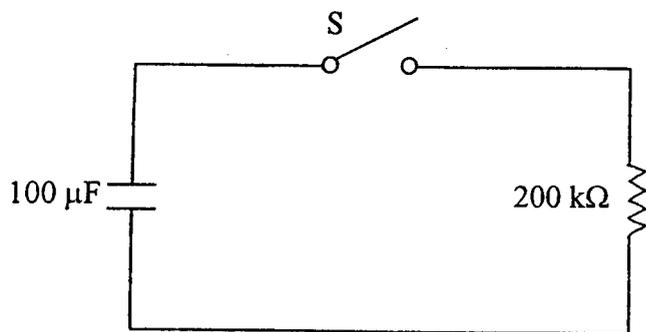
Figure 1
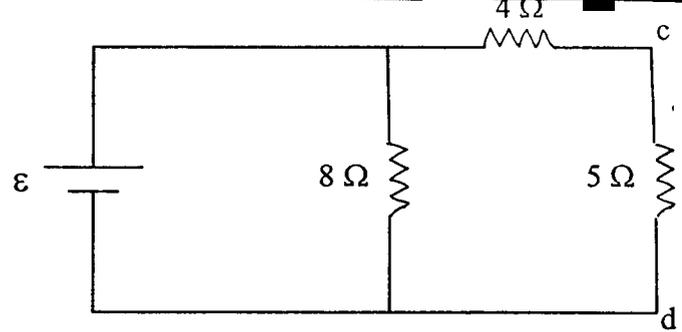
Figure 2
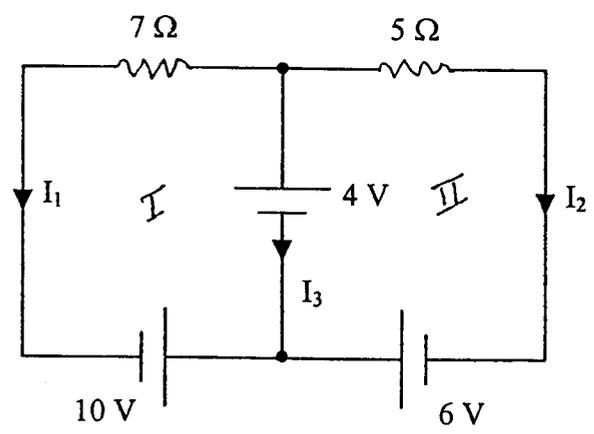
Figure 3
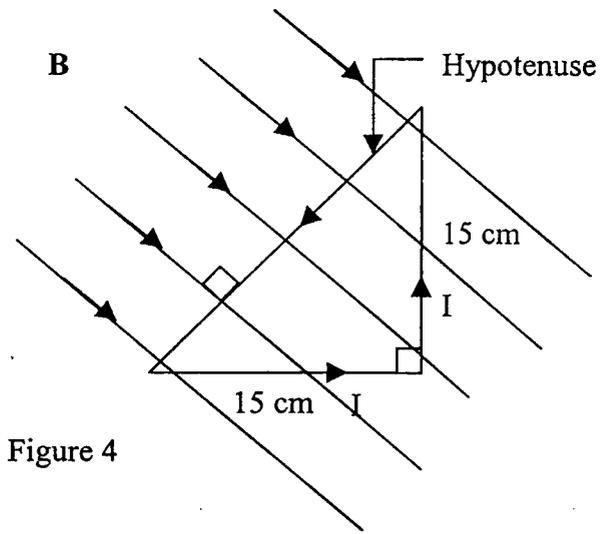
Figure 4
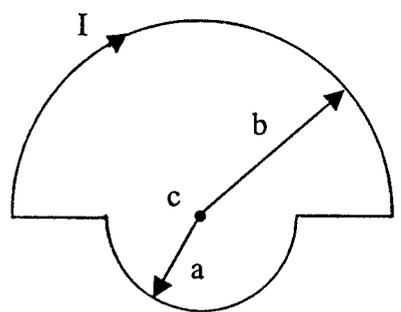
Figure 5
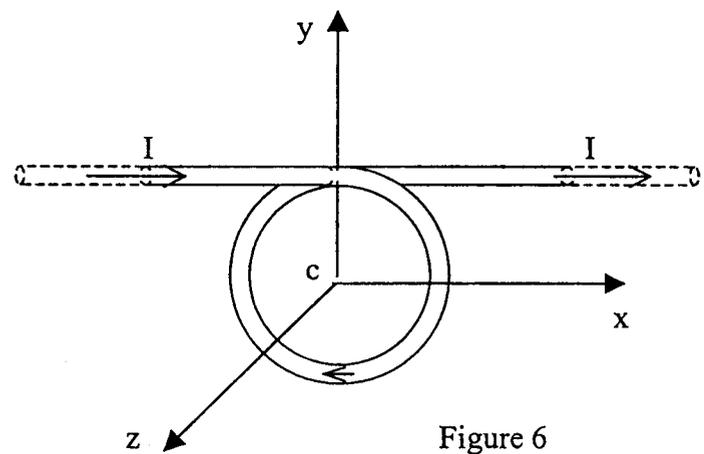
Figure 6
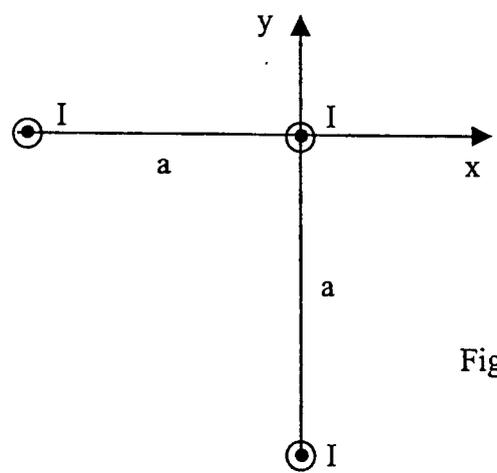
Figure 7

Figure 8

Column 1:
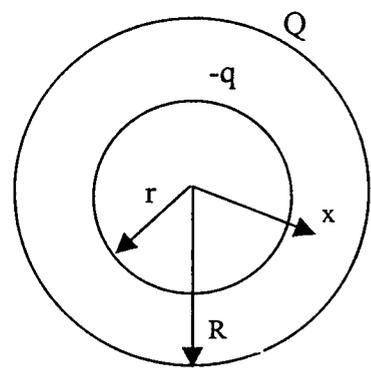
$$v = \sqrt{\frac{F}{\mu}} \qquad v = \lambda f$$

$$v = \sqrt{\frac{Y}{\rho}} \qquad v = \sqrt{\frac{B}{\rho}}$$

$$S = S_m \cos(kx - \omega t)$$

$$I = \frac{Power}{Area}$$

$$y = y_m \sin(kx - \omega t - \varphi)$$

$$P = \frac{1}{2}\mu\omega^2 A^2 v$$

$$\Delta P = \Delta P_m \sin(kx - \omega t)$$

$$\Delta P_m = \rho v \omega S_m$$

$$I = \frac{1}{2}\rho(\omega S_m)^2 v$$

$$\beta = 10 \log \frac{I}{I_0}, \quad I_0 = 10^{-12} W/m^2$$

$$f' = f\left(\frac{v \pm v_D}{v \mp v_s}\right)$$

$$y = \left(2y_m \cos\frac{\varphi}{2}\right)\sin\left(kx - \omega t - \frac{\varphi}{2}\right)$$

$$\Delta L = \alpha L \Delta T \qquad \Delta L = \frac{\lambda}{2\pi}\varphi$$

$$\Delta L = n\frac{\lambda}{2} \qquad n = 0,2,4,....$$

$$\Delta L = n\frac{\lambda}{2} \qquad n = 1,3,5,....$$

$$\Delta L = m\lambda \qquad \Delta L = \left(m + \frac{1}{2}\right)\lambda$$

$$f_n = \frac{n}{2L}\sqrt{\frac{\tau}{\mu}}, \qquad n = 1,2,3,...$$

$$f_n = \frac{nv}{2L}, \qquad n = 1,2,3,...$$

$$f_n = \frac{nv}{4L}, \qquad n = 1,3,5,...$$

$$y = 2y_m \sin kx \cos \omega t$$

$$\alpha = \frac{\Delta L}{L}\frac{1}{\Delta T}, \quad F = \left(\frac{\Delta L}{L}\right)EA$$

$$n = 1,2,3,...$$

$$PV = nRT = NkT$$

$$\beta = \frac{1}{V}\frac{\Delta V}{\Delta T}, \quad n = \frac{m}{M} = \frac{N}{N_A}$$

$$Q = mL, \quad \Delta U = Q - W$$

$$W = \int PdV,$$

Column 2:

$$P = \frac{2}{3}\frac{N}{V}\left(\frac{1}{2}m\vec{v}^2\right), \quad V_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{1}{2}m\vec{v}^2 = \frac{3}{2}k_B T, \quad \Delta U = n\,c_v\,\Delta T$$

$$Q = m\,c\,\Delta T, \qquad Q = n\,c\,\Delta T$$

$$\Delta E_{int} = Q - W, \quad \Delta E_{int} = nc_v\Delta T$$

$$C_p - C_v = R$$

$$H = \frac{Q}{t} = \kappa A \frac{T_H - T_C}{L}$$

$$Q = n\,c_p\,\Delta T, \quad Q = n\,c_v\,\Delta T$$

$$P V^\gamma = \text{constant}, \quad T V^{\gamma-1} = \text{constant}$$

$$F = \frac{9}{5}C + 32, \quad K = C + 273$$

$$W = Q_h - Q_c, \quad \varepsilon = \frac{W}{Q_h} = 1 - \frac{Q_c}{Q_h}$$

$$\frac{Q_c}{Q_h} = \frac{T_c}{T_h}, \quad (K)_{Ref} = \frac{Q_c}{W}$$

$$(K)_{Heat-Pump} = \frac{Q_h}{W}, \quad \Delta S = \int \frac{dQ_r}{T}$$

$$F = \frac{kq_1 q_2}{r^2}, \quad F = q_0 E$$

$$\varphi = \int_{Surface} \vec{E}.d\vec{A}, \quad E = \frac{kq}{r^2}$$

$$E = \frac{kQ}{R^3}r, \qquad E = \frac{2k\lambda}{r}$$

$$U = -\vec{P}.\vec{E}, \quad \varphi_c = \oint \vec{E}.d\vec{A} = \frac{q_{in}}{\varepsilon_0}$$

$$E = \frac{\sigma}{2\varepsilon_0}, \qquad E = \frac{\sigma}{\varepsilon_0}$$

$$\vec{\tau} = \vec{P} \times \vec{E}, \quad V = \frac{kQ}{r}$$

$$W = \Delta K = -\Delta U$$

$$\Delta V = V_B - V_A = -\int_A^B \vec{E}.d\vec{S} = \frac{\Delta U}{q_0}$$

$$E_x = -\frac{\partial V}{\partial x}, E_y = -\frac{\partial V}{\partial y}, E_z = -\frac{\partial V}{\partial z}$$

$$U = \frac{kq_1 q_2}{r_{12}}, \quad C = \frac{Q}{V}, \quad C = \frac{\varepsilon_0 A}{d}$$

Column 3:

$$U = \frac{1}{2}CV^2, \quad C = \kappa C_0, \quad E = \frac{E_0}{\kappa},$$

$$V = \frac{V_0}{\kappa}, \quad I = \frac{dQ}{dt}, \quad I = \frac{\Delta Q}{\Delta t}, \quad I = JA$$

$$R = \frac{V}{I} = \rho\frac{L}{A}, \qquad J = \sigma E$$

$$\rho = \rho_0[1 + \alpha(T - T_0)], \quad P = IV$$

$$q(t) = C\varepsilon[1 - e^{-t/RC}],$$

$$q(t) = q_0\,e^{-t/RC}$$

$$d\vec{F} = I\,d\vec{s} \times \vec{B}, \quad r = \frac{mv}{qB}$$

$$\vec{\tau} = \vec{\mu} \times \vec{B}, \quad \vec{\mu} = I\vec{A}$$

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\,d\vec{s} \times \vec{r}}{r^3}, \quad \oint \vec{B}.d\vec{s} = \mu_0\,i_{enc}$$

$$B = \frac{\mu_0 I}{4\pi R}\varphi, \qquad B = \frac{\mu_0 I}{2\pi a}$$

$$B_s = \mu_0\left(\frac{N}{L}\right)I = \mu_0\,n\,I$$

$$\varphi_B = \int_{Surface}\vec{B}.d\vec{A}$$

$$\varepsilon = -\frac{d\varphi_B}{dt}, \quad \varepsilon = BLv$$

$$\overline{v} = v_0 + at$$

$$x - x_o = v_o t + \frac{1}{2}at^2$$

$$v^2 = v_o^2 + 2a(x - x_o)$$

$$\varepsilon_0 = 8.85 \times 10^{-12}\,C^2/N.m^2$$
$$k = 9.0 \times 10^9\,N.m^2/C^2$$
$$q_e = -1.6 \times 10^{-19}\,C$$
$$m_e = 9.11 \times 10^{-31}\,kg$$
$$m_p = 1.67 \times 10^{-27}\,kg$$
$$1\,eV = 1.6 \times 10^{-19}\,J$$
$$1\,cal = 4.186\,J$$
$$micro = 10^{-6}, \quad nano = 10^{-9},$$
$$pico = 10^{-12}$$
$$\mu_0 = 4\pi \times 10^{-7}\,Wb/A.\,m$$
$$k = 1.38 \times 10^{-23}\,J/K$$
$$N_A = 6.02 \times 10^{23}\,molecules/mole$$
$$1\,atm = 1.013 \times 10^5\,N/m^2$$
$$R = 8.31\,J/mol.\,K$$
$$\rho(water) = 1\,g/cm^3$$
$$g = 9.8\,m/s^2$$
$$1\,cal = 4.186\,Joule$$

Q1

$$q = q_0 e^{-t/RC} = CV_0 e^{-t/RC}$$
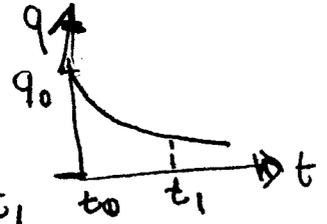
differentiate

$$\to dq = CV_0 \left(-\frac{1}{RC}\right) e^{-t/RC} dt$$

total charge flows during the first minute $= \int_{t_0}^{t_1} dq$

$$= \int_{t_0}^{t_1} \left(-\frac{V_0}{R}\right) e^{-t/RC} dt = -\frac{V_0}{R} (-RC) \left[e^{-t/RC}\right]_{t_0}^{t_1}$$

$$= V_0 C \left[e^{-t_1/RC} - e^{-t_0/RC}\right]$$

$$= (50)(100 \times 10^{-6}) \left[e^{-\frac{60}{(200 \times 10^3)(100 \times 10^{-6})}} - e^0\right] = 4.8 \, mC$$

Q2

$$r = \frac{m v}{q B}$$

mass of an electron $= m_e$

velocity of an electron before it enters the magnetic field region

charge of an electron $= e$

$$\Delta K + \Delta U = 0$$
$$K_f - K_i + q(\Delta V) = 0$$
$$\frac{1}{2} m_e v^2 - 0 - e \Delta V = 0$$
$$v = \sqrt{\frac{2e \Delta V}{m_e}}$$
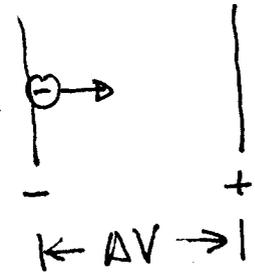
$$r = \frac{m_e}{e B} \sqrt{\frac{2e \Delta V}{m_e}} = \frac{1}{B} \sqrt{\frac{2 m_e \Delta V}{e}}$$

$$= \frac{1}{0.2} \sqrt{\frac{2(9.1 \times 10^{-31})(500)}{1.6 \times 10^{-19}}} = 0.38 \, mm$$

Q3

$$V = \frac{Q_1}{C_1}$$

$$C_2 = 2C_1$$

$$V = \frac{Q_1}{C_1}$$

$$C_{eq} = 3C_1$$
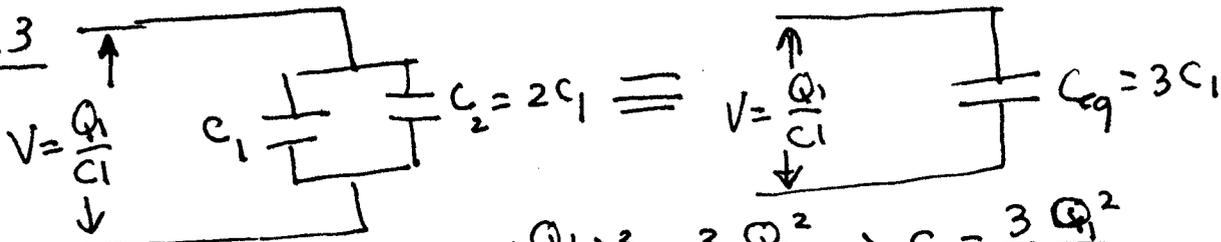
$$U = \frac{1}{2} C_q V^2 = \frac{1}{2}(3C_1)\left(\frac{Q_1}{C_1}\right)^2 = \frac{3}{2}\frac{Q_1^2}{C_1} \Rightarrow C_1 = \frac{3}{2}\frac{Q_1^2}{U}$$

$$\Rightarrow C_2 = 2C_1 = 3\frac{Q_1^2}{U} = 3\frac{(2 \times 10^{-6})^2}{12 \times 10^{-9}} = 1.0 \times 10^{-3} \, F$$

Q4 $\mathcal{E} = -\dfrac{d\phi}{dt} = -2at \Rightarrow a = -\dfrac{\mathcal{E}}{2t} = \dfrac{-48}{2(3)} = -8.0 \dfrac{V}{s}$


Q5

Force on side ①

$\vec{F} = i\vec{\ell} \times \vec{B}$
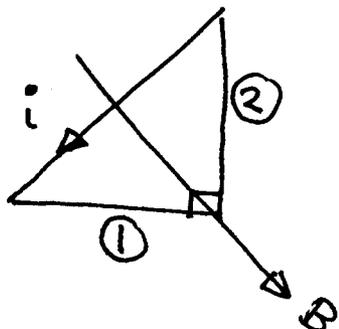
$F_1 = i\ell B \sin \theta_1$

$\quad = 2(0.15)(0.7) \sin 45°$

$\quad = 0.148 \text{ N into the plane}$

Force on side ②

$F_2 = i\ell B \sin 135°$

$\quad = 2(0.15)(0.7) \sin 135°$

$\quad = 0.148 \text{ N into the plane}$

total force on side ① and ② $= 2(0.148) = 0.30 \text{ N}$
into the plane

Q6

$F_1 = F_2 = i\ell B \sin \theta$

$\quad = i\ell \left(\dfrac{\mu_0}{2\pi} \dfrac{i}{a} \right) \sin 90°$
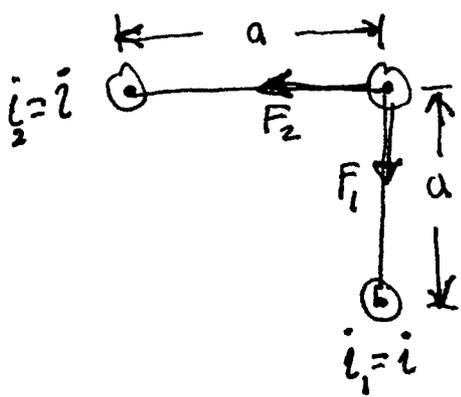
$\quad = \ell \dfrac{\mu_0}{2\pi} \dfrac{i^2}{a}$

total force $F = \sqrt{F_1^2 + F_2^2} = \sqrt{2} \, F_1$

total Force per unit length $= \dfrac{F}{\ell} = \sqrt{2} \dfrac{F_1}{\ell}$

$\quad = \sqrt{2} \dfrac{\mu_0}{2\pi} \dfrac{i^2}{a} = \sqrt{2} \dfrac{4\pi \times 10^{-7}}{2\pi} \dfrac{16^2}{1 \times 10^{-1}}$

$\quad = 0.28 \text{ N/m}$

Q7 $E_x = -\dfrac{\partial V}{\partial x} = -4z = -4(-3) = 12 \text{ V/m}$

$E_y = -\dfrac{\partial V}{\partial y} = -5 \text{ V/m}$

$E_z = -\dfrac{\partial V}{\partial z} = -4x + 6z = -4(2) + 6(-3) = -26$

$E = \sqrt{E_x^2 + E_y^2 + E_z^2} = \sqrt{(12)^2 + (-5)^2 + (-26)^2} = 29 \text{ V/m}$

Q8

7Ω @ 5Ω

i_1 ... $4v$ ... i_2

i_3

$10V$ ... $6V$
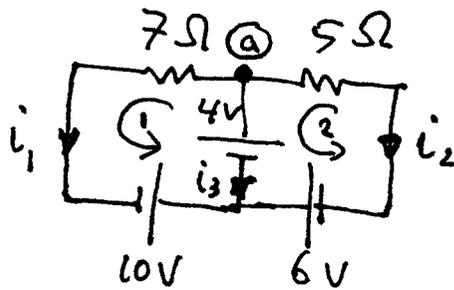
loop 1 $10 + 4 - 7i_1 = 0$
    $\Rightarrow i_1 = 2\,A$

loop 2

  $-6 + 5i_2 - 4 = 0$
   $\Rightarrow i_2 = 2\,A$.

Junction @ $i_1 + i_2 + i_3 = 0$

   $i_3 = -i_1 - i_3 = -4\,A$

Q9

$$P = IV = \frac{V}{R} V = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P} = \frac{(12)^2}{153} = 0.94\,\Omega$$

Q10

N S

$\ell = -\dfrac{d\phi}{dt} \Rightarrow d\phi = -iR\,dt$

   iR

$\Delta\phi = -iR\,\Delta t$
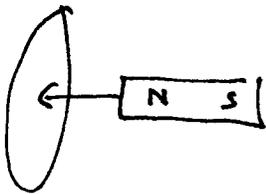
   $= (10^{-2})(0.25)(10)$

   $= 2.5 \times 10^{-2}\,Wb$

Q11   the rate of change of magnetic flux

Q12

$$y = 2\sin(1x - 40t)$$

    $\uparrow$ $\uparrow$
    k ω

tension   linear density

$$v = \sqrt{\frac{T}{\mu}} \text{ and } v = \frac{\omega}{k} \Rightarrow \sqrt{\frac{T}{\mu}} = \frac{\omega}{k}$$

$$T = \mu\left(\frac{\omega}{k}\right)^2 = (10^{-3})\left(\frac{40}{1}\right)^2 = 1.6\,N$$

wave number   angular frequency

Q13

$$B = \mu_0 i n = \mu_0 i \frac{N}{\ell} \leftarrow \text{length of the solenoid}$$

Length of the wire $= N\,(circumference)$

$$= \frac{B\ell}{\mu_0 i}\,(circumference) = \frac{(25\times10^{-3})(3)}{4\pi\times10^{-7}(12)}(9.4\times10^{-2})$$

$$= 467\,m$$

Q14 $dw = PdV \Rightarrow W = \int PdV = P \int dV = P\Delta V$

constant (over the P)

$$= 1. \, atm \left(\frac{1.01 \times 10^5 \, Pa}{1 \, atm} \right) (1.67 - 1 \times 10^{-3}) \, m^3$$

$$= 1.69 \times 10^5 \, J$$

Q15 $f' = f \left(\frac{v \textcircled{\pm} v_D}{v \pm v_s} \right)^{\nwarrow 2v} \Rightarrow f' = f \left(\frac{v + 2v}{v} \right) = 3f$

$\searrow = 0$

choose +
to make f'
larger since the detector is approaching the source

Q16 $P = \frac{F}{A} = \frac{\frac{\Delta p}{\Delta t}}{A}$ ← linear momentum

number of molecules

$$= \frac{\frac{Nm\Delta v}{\Delta t}}{A}$$ ← change in velocity

number of molecules striking per second

$$= \frac{\left(\frac{N}{\Delta t}\right) m (2v\cos\theta)}{A}$$

$\theta = 55°$

$\Delta v = v_x - (-v_x)$
$= 2v_x$
$= 2v\cos\theta$

$$= \frac{(1 \times 10^{23})(3.3 \times 10^{-27})(2(1 \times 10^3)\cos 55°)}{2 \left(\frac{10^{-4} \, m^2}{1 \, cm^2} \right)}$$

to convert to m^2

$$= 1.9 \times 10^3 \, Pa.$$

Q17

inside a conducting sphere, the potential is constant $V = k \frac{Q_0}{R_0}$

outside a conducting sphere, the potential is decreasing with the distance from the sphere $V = k \frac{Q_0}{x}$
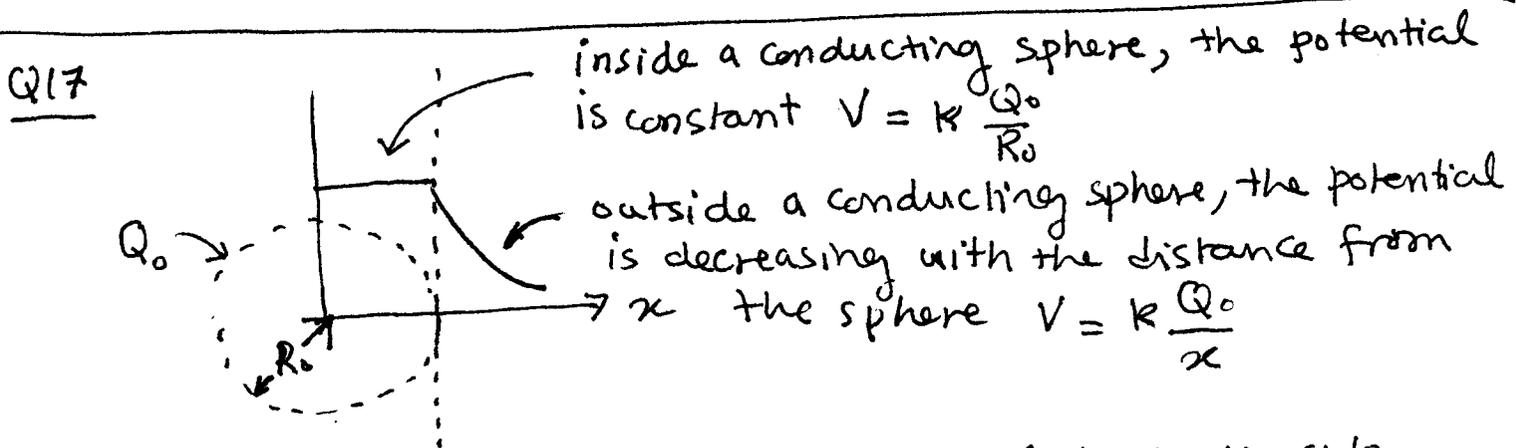
$\begin{cases} x \text{ is inside the outer sphere} \Rightarrow \text{the potential due to the outer} \\ \qquad\qquad\qquad\qquad\qquad\qquad \text{sphere } V_Q = k\frac{Q}{R}. \\ x \text{ is outside the inner sphere} \Rightarrow \text{the potential due to the inner} \\ \qquad\qquad\qquad\qquad\qquad\qquad \text{sphere } V_{-q} = k\frac{(-q)}{x}. \end{cases}$

total potential $= V_Q + V_{-q} = k \left(\frac{Q}{R} - \frac{q}{x} \right)$

Q18

$$i_1 = \frac{V_c - V_d}{5\Omega} = \frac{6}{5} A$$

$$\varepsilon - i_1(4) - i_1(5) = 0$$

$$\varepsilon = i_1(9) = \frac{6}{5} 9 = 10.8V$$

Q19

$-50e$
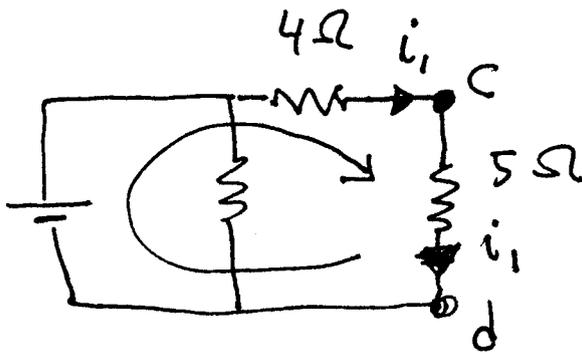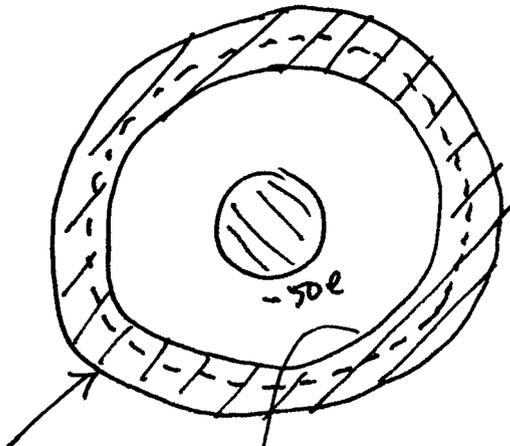
For electrostatic case, the electric field inside conductor $= 0 \Rightarrow$ flux through a Gaussian surface inside the conductor $= 0 \Rightarrow$ charge inside this Gaussian surface $= 0$.

the net charge on the shell $= -100e$

$=$ charge on the outer surface of the shell + charge on the inner surface of the shell.

$\Rightarrow$ charge on the outer surface
$= -100e -$ charge on the inner surface

charge on the inner surface of the shell + charge on the surface of the sphere $= 0$

$\Rightarrow$ charge on the inner surface of the shell $= -$ charge on the surface of the sphere
$= -(-50e) = +50e$

$= -100e - (+50e) = -150e$.

Q20
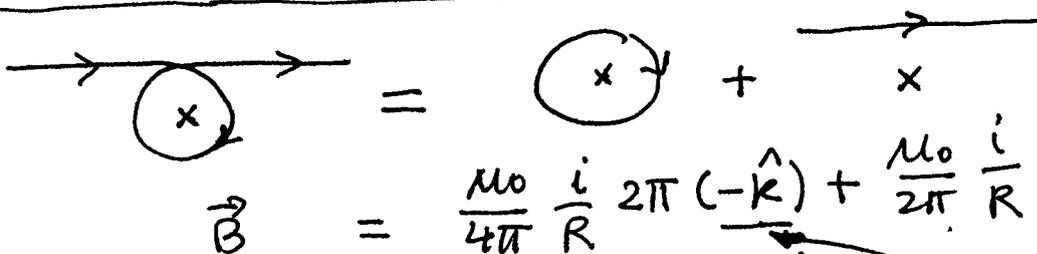
$$\vec{B} = \frac{\mu_0}{4\pi} \frac{i}{R} 2\pi (-\hat{k}) + \frac{\mu_0}{2\pi} \frac{i}{R} (-\hat{k}) \quad \text{using right-hand rule}$$

$$= \frac{\mu_0 i}{2R} \left(1 + \frac{1}{\pi}\right)(-\hat{k})$$

$$= \frac{(4\pi \times 10^{-7})(5.3)}{2(0.1)} \left(1 + \frac{1}{\pi}\right)(-\hat{k})$$

$$= -4.4 \times 10^{-5} \hat{k}$$

Q21
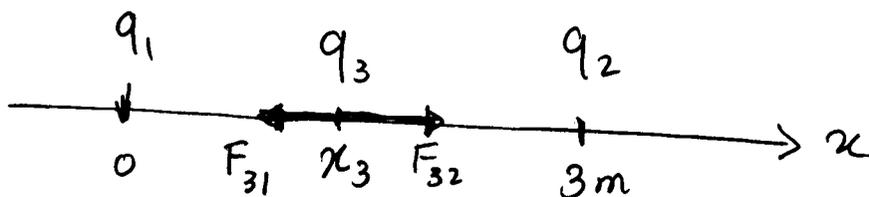
$$F_{32} = F_{31}$$

$$\cancel{K}\frac{q_2 \cancel{q_3}}{(3-x_3)^2} = \cancel{K}\frac{q_1 \cancel{q_3}}{x_3^2} \Rightarrow \frac{q_1}{q_2} = \left(\frac{x_3}{3-x_3}\right)^2$$

$$\Rightarrow \sqrt{\frac{q_1}{q_2}} = \frac{x_3}{3-x_3} \Rightarrow \sqrt{\frac{12}{3}} = \frac{x_3}{3-x_3}$$

$$\Rightarrow 2 = \frac{x_3}{3-x_3} \Rightarrow 6-2x_3 = x_3 \Rightarrow x_3 = 2$$

Q22 $\mu = iA = i\left(\frac{\pi a^2}{2} + \frac{\pi b^2}{2}\right) = \frac{i\pi}{2}(a^2 + b^2)$

$$= 19\frac{\pi}{2}\left((3\times\omega^{-2})^2 + (5\times\omega^{-2})^2\right) = 0.10 \ A\cdot m.$$

Right-hand rule :-

- Put your four straight fingers of your right hand along the direction of the current.
- The inner side of your hand should face the loop
- your thumb points along $\vec{\mu}$.

$\vec{\mu}$ points into the page.

Q23 A magnetic field cannot change the kinetic energy of a charge

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Q24 1, 2 and 5

Q25 2, 3 and 5

$\overrightarrow{P} \Longleftrightarrow E$ $\overrightarrow{P} \Longrightarrow E$
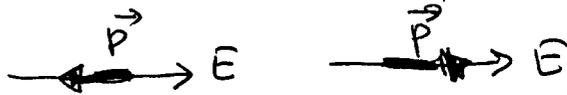
Q26 $U = -\overrightarrow{P} \cdot \overrightarrow{E}$

$\Delta U = (-pE\cos(80)) - (-pE\cos 0)$

$= 2pE = 2q\,dE = 2(9.3\times 10^{-12})(1.\times 10^{-3})\cdot 1100$

$= 2.05 \times 10^{-11} J$

Q27 $\overrightarrow{F} = q\,\overrightarrow{v} \times \overrightarrow{B}$

$= -1.6\times 10^{-19}(5\times 10^5 \,\hat{\imath} + 3\times 10^5 \hat{\jmath}) \times (0.8\,\hat{k})$

$= -1.6\times 10^{-19}((5\times 10^5)(0.8)(\hat{\imath}\times\hat{k}) + (3\times 10^5)(0.8)(\hat{\jmath}\times\hat{k}))$

$= -6.4\times 10^{-14}(\hat{\imath}\times\hat{k}) - 3.84\times 10^{-14}(\hat{\jmath}\times\hat{k})$

$= 6.4\times 10^{-14}\hat{\jmath} - 3.84\times 10^{-14}\,\hat{\imath}$

| $\hat{\imath}\times\hat{k} = -\hat{\jmath}$
| $\hat{\jmath}\times\hat{k} = \hat{\imath}$

$F = \sqrt{F_x^2 + F_y^2}$

$= \sqrt{(3.84\times 10^{-14})^2 + (6.4\times 10^{-14})^2} = 7.46\times 10^{-14} N$

Q28   1, 2 and 3

Q29   Conservation of charge

Q30 $B = \dfrac{\mu_0}{2\pi}\dfrac{i}{R_0} = \dfrac{\mu_0}{2\pi}\dfrac{J\pi R^2}{R_0}$

$= \dfrac{4\pi\times 10^{-7}}{2\pi}\dfrac{2\times 10^4 \,\pi\,(4\times 10^{-3})^2}{5\times 10^{-3}}$

$= 40\times 10^{-6} T = 40\,\mu T$

$R = 4\,mm$

$5\,mm = R_0$