BITS, PILANI – DUBAI CAMPUS
KNOWLEDGE VILLAGE, DUBAI

I-Year II-Semester
COMPREHENSIVE EXAM

Course Name:	Physics II;	**Course No.:**	PHY UC132;
Date:	6th June 2004;	**Weightage:**	40%;
Max Marks:	**40**	**Duration:**	**3 hrs.**

Possibly for use

{$c = 2.998 \times 10^8$ m·s^{-1} ; $\mu_0 = 4\pi \times 10^{-7}$ N A^{-2}; $\varepsilon_0 = 8.85 \times 10^{-12}$ F·m^{-1};

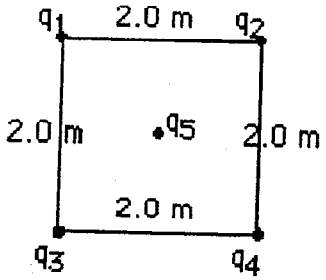
$h = 6.63 \times 10^{-34}$ J·s; $e = 1.602 \times 10^{-19}$ C; $m_e = 9.1 \times 10^{-31}$ kg; $m_p = 1.67 \times 10^{-27}$ kg}

Q1. I) When the electric charge on ***each*** of two nearby charged particles is doubled, the electric force between them is **[1]**

i. doubled.
ii. quadrupled.
iii. the same as previously.
iv. (None of the above)

II) Two solid spheres, both of radius **R**, carry identical total charges, **Q**. One sphere is a good conductor and the other is an insulator. If the charge on the insulating sphere is uniformly distributed throughout its interior volume, how do the electric fields outside these two spheres compare? Are the fields inside the two spheres identical? Explain. **[2]**

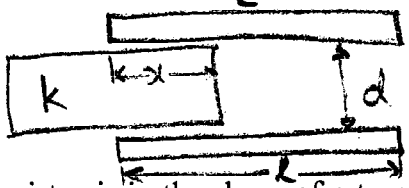
III) In the figure below, $q_1 = q_2 = -200\mu C$, $q_3 = q_4 = +100mC$ and the charge at the center of the square $q_5 = +20\mu C$. With q_5 removed in the figure, find **(a)** the potential at the center of the square and **(b)** the work done to bring q_5 from infinity to the center of the square. **[3]**



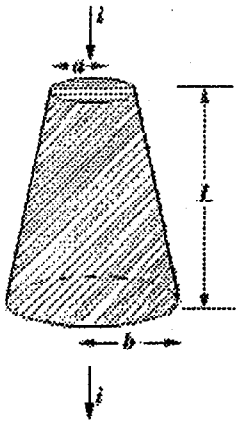
Q 2. **I)** A hollow metal sphere is charged to a potential V. The potential at its center is: **[1]**

i. V
ii. 0
iii. -V
iv. 2V
v. πV

II) A capacitor is constructed from two square plates of sides l and separation d. A material of dielectric constant k is inserted a distance x into the capacitor, as shown in the figure. Assume that d is much smaller than x. **(a)** Find the equivalence capacitance. **(b)** Find the direction and magnitude of the force exerted on the dielectric, as a function of x assuming a constant potential difference ΔV. Ignore friction. **[2]**



III) A resistor is in the shape of a truncated right circular cone. The end radii are a and b, and the altitude is L. If the taper is small, we may assume that the current density is constant across any cross section. **(a)** Calculate the resistance of this object. **(b)** Show that the answer reduces to $\rho L/A$ for the special case of zero taper $(a = b)$. **[3]**



Q 3. **I)** You are designing a magnetic probe that uses the Hall effect to measure magnetic fields. Assume that you are restricted to using a given material and that you have already made the probe as thin as possible. What, if anything, can be done to increase the Hall voltage produced for a given magnitude of magnetic field? **[1]**

II) For a Toroid of inner radius a and outer radius b, use Ampère's law to calculate the magnetic field at a distance r from the center of the toroid for **(a)** $0<r<a$; **(b)** $a<r<b$ and **(c)** $b<r$. **[2]**

III) A wire is formed into a circle having diameter of 10 cm and carries a current 5.0 A. **(a)** Calculate the torque on this wire when the dipole makes an angle of 60° with an external magnetic field of 3.0 mT. **(b)** Find the work done in rotating the dipole from this position to an orientation parallel to the field. **[3]**

Q 4. **I)** A circular loop of wire 5 cm in radius is in a spacially uniform magnetic field, with the plane of the circular loop perpendicular to the direction of the field. The magnetic field varies with time: **[2]**

B(t) a +bt, a = 0.2 T and b = 0.32 T/s

(a) Calculate the magnetic flux through the wire at time t = 0.

(b) Calculate the emf induced in the loop

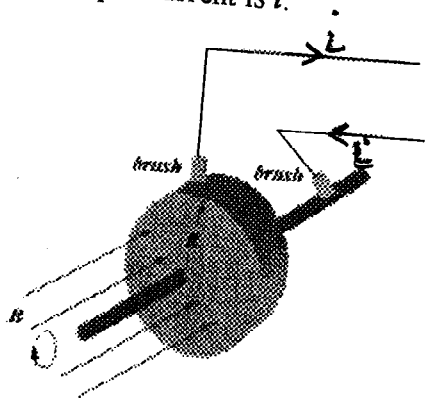
(c) If the resistance of the loop is 1.2 Ω, what is the induced current?

II) A Hindu ruler once suggested that he be entombed in a magnetic coffin such that he would be forever suspended between heaven and Earth. Is such a magnetic levitation possible? Under what conditions and where? Discuss. **[2]**

III) In the figure the device shown consists of a solid conducting disk as rotor has been shown. This machine can produce a greater emf than one using wire loop rotors, since it can spin at a much higher angular speed before centrifugal forces disrupt the rotor. **(a)** We have to show that the emf produced is given by

$$\mathcal{E} = \pi \nu B R^2,$$

where ν is the spin frequency, R the rotor radius, and B the uniform magnetic field perpendicular to the rotor. **(b)** We have to find the torque that must be provided by the motor spinning the rotor when the output current is *i*. **[3]**



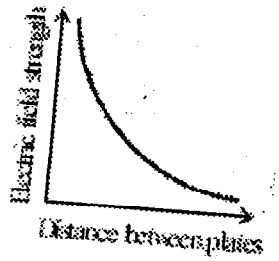
Q5. I) Write the Maxwell's equation, which involves the displacement current, and give the definition of displacement current. Make a sketch to indicate any surface or path involved in the statement of the equation or definition **[2]**

II) Explain how the loop antenna of a TV station work? Draw diagrams wherever required. **[2]**

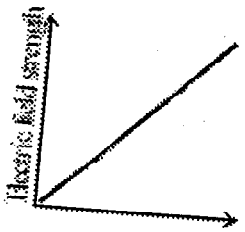
III) An electron is confined between two impenetrable walls 0.200 nm apart. Determine the energy levels for the states n =1, 2 and 3. **[3]**

Q 6. I) Two large parallel metal plates are separated by a small distance and connected to the opposite terminals of a battery. The separation between the plates is gradually increased while they still remain connected to the battery. Which of the following graphs does not depict correctly the variation indicated. **[1]**

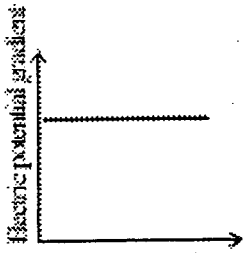
i.



ii.



iii.



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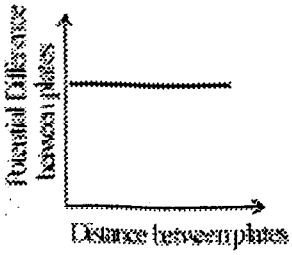


II) A thin plastic disk of radius R has a charge q uniformly distributed over its surface. If the disk rotates at an angular frequency ω about its axis, show that **(a)** the magnetic field at the center of the disk is

$$B = \frac{\mu_0 \omega q}{2\pi R},$$

and **(b)** the magnetic dipole moment of the disk is

$$\mu = \frac{\omega q R^2}{4}.$$

[3]

III) The electric field in an EM wave, traveling north oscillates in an east-west plane. Describe the direction of the magnetic field vector in this wave. If the frequency of the B field is 80.0 kHz and rms strength 9.75×10^{-9} T. What is the frequency and rms strength of the electric field? What is the average rate at which this wave carries energy across unit area per unit time? **[4]**

Physics II

I - Year II Sem 2004.

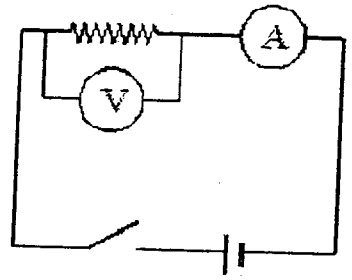
QUIZ (MAKE-UP)

PHYUC132

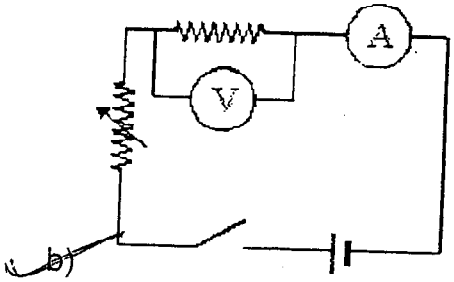
1. Ohm's Law states that:
a) All matter has resistance
b) Only metals have resistance
c) All metals have constant resistance
d) All metals have constant resistance provided temperature is constant

2. For determining whether or not current in a wire is directly proportional to the voltage applied across it, the circuit that is best used is:

a)



b)



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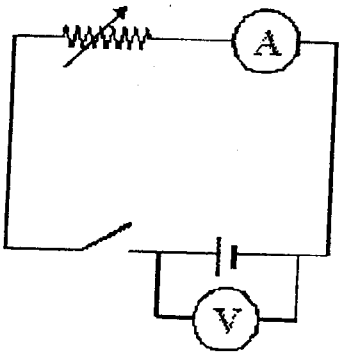
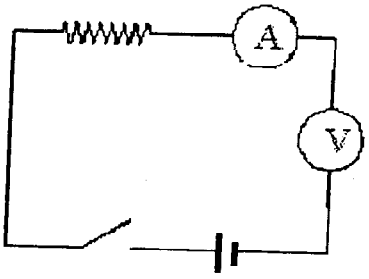
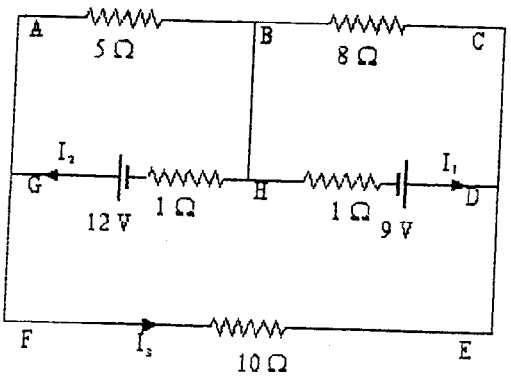


d)



3. The factors affecting resistance of a cylindrical sample of particular material are:
a) length mass and time
b) length, diameter and current
c) resistivity, temperature and length
d) temperature, diameter and length.

4. Calculate the three currents indicated in the circuit shown:



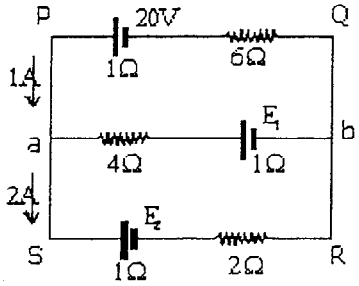
$I_1 = 0.848$

$I_2 = 2.14$

$I_3 = 0.171$

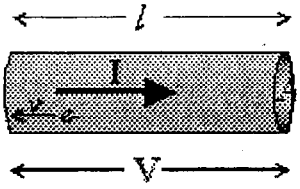
5. A current I exists in a resistor R for time t. Which of the following is not correct.
a) The charge passing any cross section per unit time is I
b) The total charge passing in this time is It
c) The total number of electrons passing any cross section in this time is It/e
d) The energy dissipated in this time is I^2R

6. Find the emf's E_1 and E_2.



$E_1 = 18V$
$E_2 = 7V$

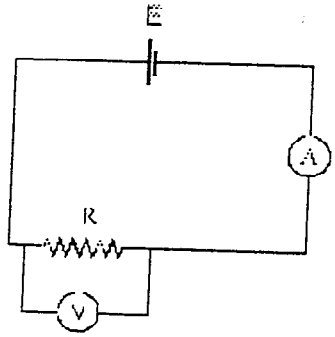
7. A cylindrical specimen of wire has length l, cross sectional area A and n free electrons per unit volume. If the potential difference V applied across its ends is increased,



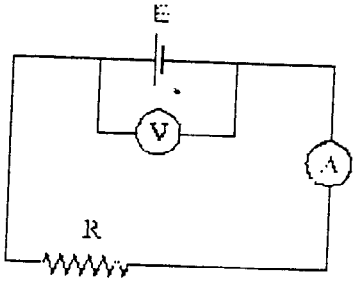
a) the current in the sample increases because the drift velocity of the electrons is reduced.
b) the current in the sample reduced because the drift velocity of the electrons is reduced.
c) the drift velocity of the electrons is increased as the electric field strength is higher.
d) the drift velocity of the electrons is incrreased as the resistivity is reduced.

8. For each of the circuits shown below, the cell has an emf E and negligible internal resistance. The meters are ideal. For which circuit do meter readings differ from those of the remaining circuits?

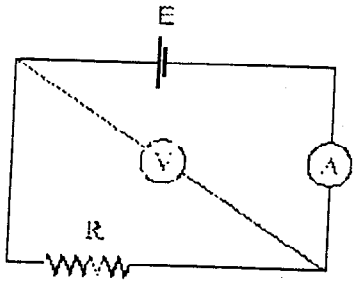
a)



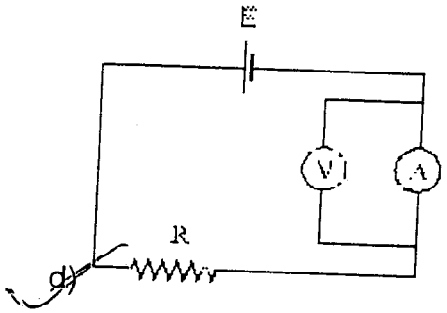
b)



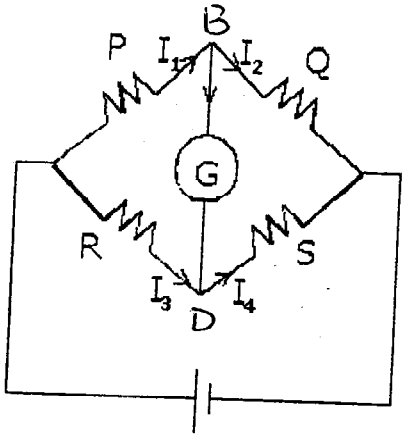
c)



d)



9. In the circuit given below,



a) there will be no current in the galvanometer because it is a Wheatstone bridge
b) there will be no current in the galvanometer because it is a potentiometer circuit
c) there will be no current in the galvanometer unless $R_1/R_2=R_3/R_4$
d) there will be nocurrent in the galvanometer unless B and D are at different potentials.

10. The electrostatic potential energy stored in a charged capacitor is given by

a) $\frac{1}{2}CV^2$

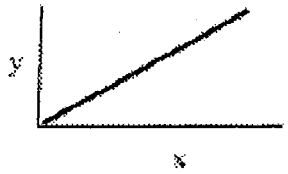
b) $\frac{1}{2}QV^2$

c) $\frac{V^2}{2Q}$
d) mgh

11. Additional charge given to the capacitor causes
a) increase of capacitance
b) decrease of capacitance
c) no change in capacitance
d) no change in potential difference across the capacitor plates

12. The capacitance C of a parallel plate capacitor is given by the expression $C = \frac{k\varepsilon_0 A}{d}$ In this expression,
a) ε_0 is the dielectric constant of the medium separating the plates
b) ε_0 is the permittivity of the medium between the plates
c) d is the diameter of each plate
d) A is the area of plate overlap

13.



The sketch graph above shows the variation of electrostatic potential difference between the capacitor plates with respect to the charge on one of the plates in the case of
a) Only a parallel plate capacitor
b) Only aspherical capacitor
c) Only a cylindrical capacitor
d) All of the above

14. The plates of a capacitor are connected to the opposite terminals of a cell. Which of the following statements is true?
a) There is no work done by the cell in charging the capacitor
b) There is no energy stored on the capacitor
c) Each plate attains the same potential as the terminal to which it is connected
d) The energy supplied by the cell dissipates through the capacitor

15. A capacitor comprises two concentric metallic shells of internal and external radii r and R, the space between them being filled with a medium of dielectric constant k. Which of the following is not correct?

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I-Year II-Semester
TEST II (Open Book)

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Date:	25th April 2004;	**Weightage:**	20%;
Test No.:	TEST II;	**Max Marks:**	30

Note: Only one Book is allowed. Written or zeroxed material should be allowed.

$\varepsilon_o = 8.85 \times 10^{-12}$ F/m

Q 1. How does the polarization of the dielectric surrounding a charged conductor affect **(a)** the effective surface charge causing the field through the dielectric, **(b)** the potential of the conductor? **[2]**

Q 2. **(a)** How can a current loop be used to determine the presence of a magnetic field in a given region of space? **(b)** Is it possible to orient a current loop in a uniform magnetic field such that the loop will not tend to rotate? **[2]**

Q 3. During solar flares a storm of charged particles is sent from the sun towards Earth, which would destroy the power distribution. **(a)** What protects us from these charged particles? (Explain in two sentences). **(b)** Also draw a sketch of the same. **(c)** What is this effect called? **(d)** Which is the natural phenomenon associated with this effect? **[3]**

Q 4. A proton with a speed of 2.2×10^6 m/s is shot into a region between two plates that are separated by distance of 0.18 m, as shown in the figure. What must be the magnitude of the magnetic field, so the proton just misses colliding with the opposite plate? **[3]**

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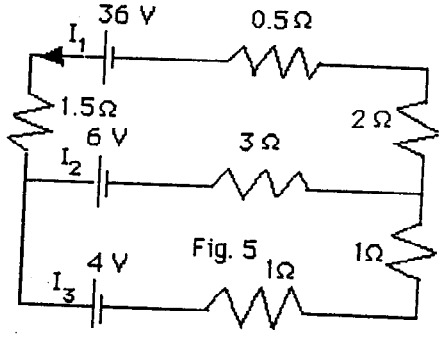

Fig. 5

[5]

Q 6. The parallel plates of a capacitor have an area of $0.2 m^2$ and are 10^{-2} m apart. The original p.d. between them is 3000V and it decreases to 1000V when a sheet of

dielectrtic is inserted between the plates. Find **(a)** the original capacitance C_o **(b)** the charge Q on each plate. **(c)** the capacitance C after insertion of dielectric **(d)** dielectric constant k **(e)** permittivity ε of the dielectric **(f)** original electric field E between the plates. **(g)** electric field E after insertion of dielectric.(ε_o=8.85x10^{-12} Vm^{-1}) [5]

Q 7. A particle with a mass m = 2.0 x 10^{-12} kg velocity v = 10^6 m/s and charge q = 10^6 C enters region 1 between the parallel plates where there is an electric field E = 10^6 N/C. Find **(a)** the direction and magnitude of the magnetic field B perpendicular to the velocity of the particle in Region 1 that allows the particle to pass through Region 1 without a deflection, **(b)** the direction of the deflection of the particle with B as found in (a) if its velocity is **(i)** 5 x 10^5 m/s and **(ii)** 5 x 10 m/s. The particle now enters Region 2 where there is no electric field, but a magnetic field B' = 2.0 T perpendicular to v. The magnitude of v is again 10^6 m/s. **(c)** What is the direction of B' to make the particle go in a counterclockwise circular path? **(d)** What is the radius of the circle? [5]

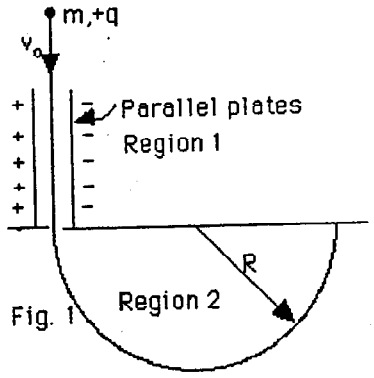

Fig. 1

Q 8. Two smooth conducting rails a distance L = 2.0 m apart make an angle of 22.5° with the horizontal. A bar of mass 1.2-kg rests across the rails, as shown in figure below. There is a uniform magnetic field vertically upward equal to 0.50 N-s/C-m. A battery is connected to cause a current I to flow through the bar as shown. **(a)** Draw a side view of the bar and indicate the cause and direction of each force that acts on it. The rod slides without friction. **(b)** What current I will allow the bar to remain at rest? **(c)** If the coefficient of friction between the rails and the rod is 0.2, and the current in the rod remains unchanged, what strength of magnetic field would keep the rod from sliding down? [5]

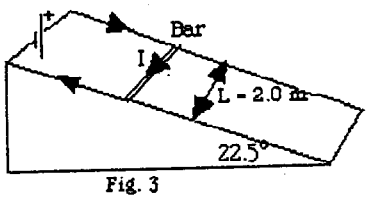

Fig. 3

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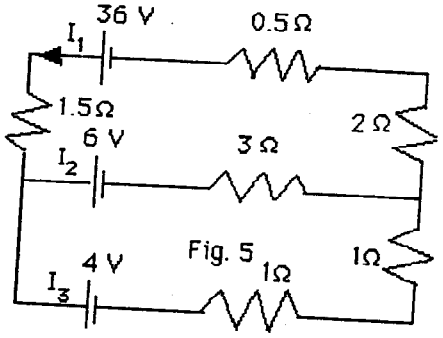

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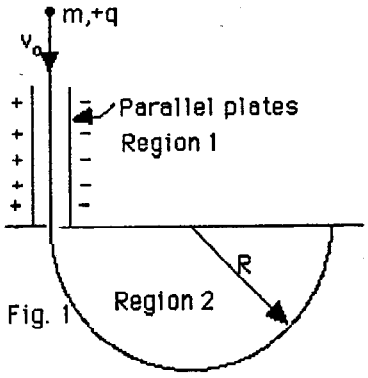

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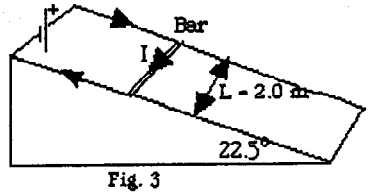

Fig. 3