TRINITY COLLEGE NABBINGO
'A' LEVEL PHYSICS SEMINARY ON SATURDAY 6TH JULY 2024

MECHANICS

1. (a) State the conditions for each of the following to be conserved.
   - (i) linear momentum *(1 mark)*
   - (ii) mechanical energy of a body in motion. *(1 mark)*

   (b) (i) State Newton's laws of motion. *(3 marks)*
   - (ii) A particle X of mass 100g initially moving with a speed of 10ms^{-1} to the East collides with particle Y of mass 200g moving at 15ms^{-1} to the south. After collision X moves with a speed 5ms^{-1} on a bearing of 060^o while Y moves with a speed of V in the direction of S$(90 - \boldsymbol{\theta})^o$ E. Determine the values of V and θ. *(6 marks)*

   (c) (i) A stone is projected vertically upwards from a point 980m above the ground with a velocity of 49ms^{-1}. Find how long it will take to reach the ground. *(5 marks)*
   - (ii) Explain what happens to a satellite when it falls to an orbit of a smaller radius. *(4 marks)*

2. (a) (i) Explain the terms damped and forced oscillations. *(4marks)*
   - (ii) Sketch displacement- time graphs for under damped and over damped oscillations. *(2 marks)*

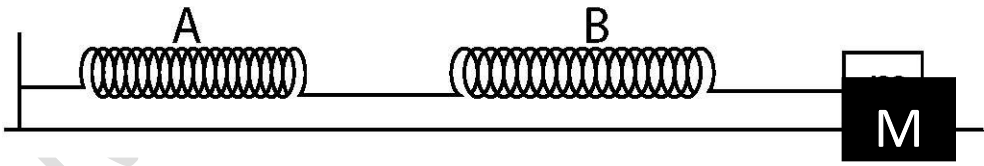
   b) 

Fig 2

Two springs **A** and **B** of spring constants $\mathbf{K_1}$ and $\mathbf{K_2}$ respectively are connected to a mass **M** as shown above. The surface on which the mass slides is friction less.

- (i) Show that when the mass is displaced slightly it oscillates with simple harmonic motion of frequency **f** given by; *(5marks)*

$$f = \frac{1}{2\pi}\sqrt{\frac{k1\,k2}{m(k1+k2)}}$$

- (ii) If the two springs have constants 50Nm^{-1}and 100Nm^{-1} respectively and the mass m=50g is displaced by 4.0cm and released, calculate its maximum speed. *(3marks)*
- (iii) Sketch a graph of velocity against displacement for a body performing

simple harmonic motion. *(1mark)*

(d) A glass U-tube contains a liquid. Air is gently blown into one of the limbs, and on releasing the pressure, the liquid oscillates in the tube.

(i) Show that the liquid oscillates with simple harmonic motion. *(4marks)*

(ii) Explain why the oscillations eventually die out. *(1mark)*

3. (a) (i) State Newton's law of gravitation. *(1mark)*

(ii) The moon moves in a circular orbit of radius, R, about the earth of mass M_e with period T, show that $R^3 = \frac{gr_e^2\ T^2}{4\pi^2}$, where $r_e =$ radius of the earth, g is acceleration due to gravity on the earth's surface. *(5marks)*

(b) (i) What is meant by gravitational field strength? *(1mark)*

(ii) Draw a sketch graph to show how the gravitational field strength varies with distance from the earth's surface for points external to it. *(2marks)*

(iii) Given that the radius of the earth is 6400km and that the values of the acceleration due to gravity at its surface is 9.81ms^{-2}, calculate a value for the acceleration due to gravity at a point 400km above the earth's surface. *(4marks)*

(c) Why does acceleration due to gravity vary with location on the surface of the earth? *(2marks)*

(d) (i) What is centripetal force? *(01mark)*

(ii) A car travels round a bend banked at an angle of 25^0. If the radius of curvature of the bend is 65m and the coefficient of friction between the tyres of the car and the road surface is 0.35, calculate the maximum speed at which the car negotiates the bend without skidding. *(4marks)*

4. Explain using the molecular theory the laws of solid friction. *(3 marks)*

(a) (i) Define surface tension. *(1 mark)*

(ii) Explain the origin of surface tension. *(3 marks)*

(b) Explain why rain drops hit the ground with less force than they should. *(4 marks)*

5. A metal sphere of radius 3.0×10^{-3}m and mass 4.0×10^{-4}kg falls under gravity, centrally

down a wide tube filled with a liquid at room temperature (25^0C). The density of the liquid is $800kgm^{-3}$. The sphere attains a terminal velocity of $45cms^{-1}$. The tube is emptied and filled with another liquid of density $1000kgm^{-3}$ at the same temperature. When the metal sphere falls centrally down the tube, it's found to attain a terminal velocity of $20cms^{-1}$.

(i) Determine the ratio of the coefficient of viscosity of the second liquid to that of the first liquid at room temperature. *(5marks)*

(ii) Describe the capillary rise method of determining surface tension of water and state any assumptions made. *(5marks)*

HEAT

5. (a) State any two ways in which real gases differ from an ideal gas. [2]

(b) Using the same axes, sketch pressure versus volume graphs for a real gas;

(i) **Above** the critical temperature, **at the** critical temperature and **below** the critical temperature. [3]

(ii) Indicate in your sketch in (i) above, the different phases of the gas. [2]

(c) An ideal gas at a pressure of 2.0×10^5 Pa occupies a volume of 3.0×10^{-3} Pa at 50.2˚C. The gas expands adiabatically to a final pressure of 1.5×10^7 Pa. The ratio of the specific heat capacity at constant pressure to that at constant volume is 1.40.

Calculate

(i) The number of moles of the gas [2]

(ii) The final volume of the gas. [3]

(iii) The final temperature of the gas. [3]

(c) (i) State Dalton's law of partial pressures. [1]

(ii) Two metallic bulbs of volumes $3.0m^3$ and $8.0\ m^3$ respectively are joined together by a narrow tube of negligible volume. The bulbs contain air at a temperature 23˚C and pressure 1.01×10^5 Pa.

Calculate the resulting pressure in the bulbs when the temperature of the smaller bulb is raised to 100˚ C and that of the larger bulb lowered to 0˚ C. State any assumption made. [4]

6. (a) (i) State the thermometric property used in the constant-volume gas thermometer 1]

(ii) Give two characteristics of a good thermometric property. [2]

(b) (i) Describe the steps taken to set up a Celsius scale of temperature for a mercury-in-glass thermometer. [4]

(ii) State four disadvantages of mercury-in-glass thermometer. [2]

(c) Describe with the aid of a labelled diagram the operation of an optical pyrometer. [6]

(d) The brake linings of the wheels of a car of mass 800 kg have a total mass of 4.8 kg and are made of a material of specific heat capacity $1200\ J\ kg^{-1}\ K^{-1}$. If the car is at 15 ms-1 and is brought to rest by applying the brakes, calculate the maximum possible temperature rise of the brake linings. [4]

7. (a) (i) Define specific latent heat of vaporization. [1]

(ii) With the aid of a well labelled diagram, describe the accurate method of determining the specific latent heat of vaporization of water. [5]

(b) Warm water and cold water flow are into a bath tab at the same time. Warm water flows at a rate of 3.5 kg min^{-1} at a temperature of 60ºC, while cold water flows out at a rate of 4.2 kg min^{-1}. When the water has been flowing for 40.0 seconds, the temperature of the water in the tab is found to be 35.0ºC. If the water in the tab loses heat at an average rate of 100W, find,

(i) The mass of water in the tab after 40.0 seconds. [2]

(ii) The temperature of the cold water. [4]

(c) Define thermal conductivity of a material and state its units. [2]

(d) A house has a concrete floor of area $40.0m^2$ and thickness 10.0cm. The temperature inside the room is 25ºC while that just below the concrete is 20ºC. If 1.02×10^5 Joules of heat are lost through the concrete every minute, find;

(i) The conductivity of concrete. [3]

(ii) The thickness of extra concrete needed to reduce the rate of heat flow through the concrete by 40%. [3]

MODERN PHYSICS

1. (a) Define the following terms as used in radioactivity.

(i) Isotopes (ii) Half-life, and (iii) Mass number.

(b) With use of a labeled diagram describe how a Geiger Muller tube is used to detect radiation from a radioactive material.

(c) The radioactive Strontium $^{90}_{38}$ Sr decays by emission of beta particles to form an element$X$.

(i) Write the equation representing the decay process above.

(ii) If the half-life of $^{90}_{38}$ Sr is 28.8 years, determine the current activity of a sample of 2.5µg of $^{90}_{38}$ Srobtained 15 years ago.

(d) (i) State two industrial uses and two health hazards of radioactivity.

(ii) Given the equation $N = N_o e^{-\lambda t}$, show that half-life$t_{\frac{1}{2}} = \frac{\text{In}2}{\lambda}$.

2. a (i) Define thermionic emission

(ii) Explain briefly the mechanism of thermionic emission

b (i) sketch the current – potential difference characteristics of a thermionic diode for two different operating temperatures and explain the main features
(ii) Describe one application of a diode

(c) Sketch a graph of intensity versus frequency of radiation produced in an x- ray tube and explain its features
(d) A monochromatic x- ray beam of wavelength 1.0×10^{-10} m is incident on a set of planes in a crystal of spacing 2.8×10^{-10} m .Find the maximum order possible with these x- rays.

3. a Define the following
(i) Fusion reaction
(ii) Fission reaction

(b) Sketch the variation of binding energy per nucleon against mass number and use it to explain the stability of the atom
C (i) What is meant by photoelectric effect

(ii) Write down Einstein's photoelectric equation for field emission and define each term

(iii) Describe an experiment based on Millikan's experiment to verify Einstein's equation for photoelectric effect
(d) Calculate the de Broglie wavelength of an electron moving at 3.0×10^{6} ms^{-1} . Plank's constant = 6.6×10^{-34} Js ,mass of an electron 9.11×10^{-31} kg

4. (a) (i) With the aid of a labelled diagram describe the functions of the main parts of a C.R.O

(ii) What advantages does a C.R.O have over ordinary meters when used as a voltmeter?

(b) Explain the use of a time-base circuit in a cathode ray oscilloscope

(c) With the time base switched off, an alternating voltage with root-mean-square value 2.82 V is connected across the Y-plates of a C.R.O. If a vertical trace of length 4.0 cm is formed on the screen, find the value at which the gain control of the C.R.O is set.

(d) (i) What are positive rays?

(ii) In a Bain bridge mass spectrometer, singly ionized atoms of ${}^{35}_{17}Cl$ and ${}^{37}_{17}Cl$ pass into the deflection chamber with a velocity of 10^{5} ms^{-1}. If the magnetic flux density in the chamber is 0.8 T, calculate the difference in the radii of the paths of the ions.

5. (a) (i) Define Avogadro's constant and Faraday's constant.
(ii) Show that the charge carried by a monovalent ion is 1.6×10^{-19}C.

(b) (i) Define specific charge of an electron and state its units.

(ii) With use of a labeled diagram, describe Thomson's experiment to determine the specific charge of an electron.

(c) A charged oil drop of density $800kgm^{-3}$ is held stationary between two parallel plates 5.0mm apart held at a potential difference of 105V. When the electric field is switched off, the drop is observed to fall a distance of 2.5mm in 36.0 seconds (viscosity of air = $1.8 \times 10^{-5}Nsm^{-2}$, density of air = $1.29kgm^{-3}$)

(i) Calculate the radius of the drop.
(ii) Estimate the number of excess electrons on the drop.

6. (a) Define the terms below as applied to a triode
(i) Space charge
(ii) Amplification factor
(iii) Mutual conductance

(b) With the aid of a labeled diagram explain full wave rectification
(c) Derive an expression for the amplification factor μ in terms of anode resistance Ra and mutual conductance g_m for a triode valve.

(d) A triode with mutual conductance $3mAV^{-1}$ and anode resistance of 10kΩ is connected to a load resistance of 20kΩ. Calculate the amplitude of the output signal, if the amplitude of the input signal is 25mV

(e) i) Sketch the output characteristics of a transistor
(ii) Identify on the sketch in e(i) the region over which the transistor can be used as an amplifier.

7. (a) State Bohr's postulates of the hydrogen atom.
(b) Define the terms **ionization energy** and **excitation energy**.
(c) The energy levels in a mercury atom are -10.4 eV, -5.5 eV, -3.7 eV and -1.6 eV.
(i) Find the ionization energy of mercury in joules.
(ii) What is likely to happen if a mercury atom in unexcited state is bombarded with an electron of energy 4.0 eV, 11.0 eV?

(d) (i) Explain the successes and failures of Rutherford's model of an atom.

(ii) Show that when the $\alpha -$ particles collide head on with an atom of atomic number Z, the closest distance of approach to the nucleus $x$is given by$x = \frac{Z e^2}{\pi \varepsilon_0 m v^2}$, where e is the electronic charge, m the mass of an electron and v, the velocity of $\alpha -$ particles.
(e) Explain the emission spectrum of hydrogen.

PAPER 2

SECTION A

1 (a) What is meant by the following as applied to refraction through a prism?

(i) ***Refracting angle.*** (1)

(ii) ***Deviation.*** (1)

(b) (i) Briefly describe the adjustments that have to be made before using the prism spectrometer. (3)

(ii) Describe an experiment to determine the refractive index of glass in form of a prism of known refracting angle, using the prism spectrometer. (6)

(c) A ray of light is incident at a small angle of incidence on a prism of small angle, A. If the refractive index of the prism material is n, derive an expression for the deviation produced. (4)

(d) A ray of light is incident on a prism of refractive index **1.5** and refracting angle **60^o**. The ray emerges from the prism at an angle of **65^o**. Find;

(i) the angle of incidence (3)

(ii) the deviation of the ray (2)

2. (a) For a converging lens, what is meant by

(i) **principal focus.** (1)

(ii) **radii of curvature.** (1)

(b) A convex lens of focal length, f, forms an image on a screen of an object which is at a distance, y, from the screen. Derive an expression for the distance, y, for the image to always be real.(4)

(c) Describe an experiment to determine the focal length of a diverging lens with the help of a converging mirror. (5)

(d) A combination consists of two thin lenses, one convex and the other concave, each of focal length **20 cm** and placed co-axially with their centers **20 cm** apart. An object is placed on the common axis at a distance of **30 cm** from the convex lens on the side remote from the concave lens.

(i) Sketch a ray diagram to illustrate the path of the rays through the combination. (2)

(ii) Find the nature and position of the final image formed. (5)

(iii) What is the magnification produced by the combination? (2)

3(a) Explain with the aid of suitable diagrams, the terms principal focus and conjugate points as applied to a converging lens. (3)

(b) Three thin lenses L_1, L_2 and L_3 are arranged co-axially as shown in **figure 1** below.

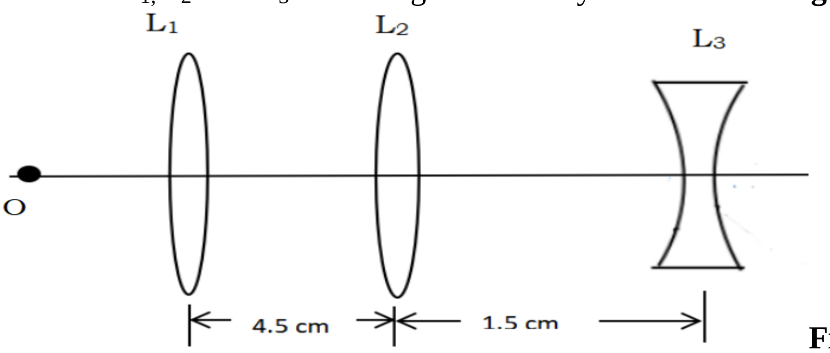


Fig. 1

The focal lengths of the lenses are **20.0 cm**, **15.0 cm** and **5.0 cm** respectively. An object, O, is placed at a distance of **30 cm** from L_1. Find the position, size and nature of the final image formed by the system of lenses. (8)

(c) (i) Define the term angular dispersion of a ray of light. (1)

(ii) Calculate the angular separation of the red and violet rays which emerge from a $\mathbf{60^0}$ glass prism when a ray of white light is incident on the prism at angle of $\mathbf{45^0}$.The material of the glass prism has a refractive index of **1.64** for the red light and **1.66** for the violet light. (4)

(d) Show that when a ray of light passes nearly normally through a prism of small angle, $\boldsymbol{\alpha}$, and refractive index, **n**, the deviation, **d** is given by $\boldsymbol{d = (n - 1)\,\alpha}$. (4)

4(a) (i) Describe briefly some form of a reflecting telescope, explaining the function of each part. (5)

(ii) Draw a ray diagram to show the formation of the image of an object point on the axis of the telescope described in a(i)abov (1)

(iii) What advantages does a reflecting telescope have over a refracting telescope? (3)

(b) (i) Define the term angular magnification of a telescope. (2)

(ii) Derive an expression for the angular magnification of a simple astronomical telescope in normal adjustment. Express your results in terms of the focal lengths of the lenses. (4)

(c) An astronomical telescope consists of lenses of focal lengths **100.0 cm** and **10.0 cm**.

(i) How far apart must the lenses be placed is the image of a star is to be formed **200 cm** from the eye lens? (3)

(ii) What is the angular magnification of the telescope in c(i) above (2)

SECTION B

1(a) (i) What is meant by interference of waves? (2)

(ii) State the conditions necessary for the observation of interference pattern. (2)

(iii) Describe how interference can be used to test for the flatness of a surface. (3)

(b) Describe with the aid of a labeled diagram, how the wavelength of monochromatic light is measured using Young's double-slit method. (5)

(c) Two microscope slides are in contact at one end and are separated by a thin piece of paper at the other end. Monochromatic light is directed normally on the wedge.

(i) What type of fringes will be observed? (2)

(ii) Explain what will be observed if a liquid is introduced between the slides 2

(d) When monochromatic light of wavelength 5.0×10^{-7}m is incident normally on a transmission grating, the second order diffraction line is observed at an angle of 27^0. How many lines per centimeter does the grating have? (4)

2(a) What is meant by

(i) ***wavelength*** of a wave. (1)

(ii) ***pitch*** of a musical note (1)

(b) (i) A source of sound of frequency f, is moving with velocity u_s away from an observer who is moving with velocity u_o in the same direction. If the velocity of sound is V, derive

an expression for the frequency of sound heard by the observer.
(5)

(ii) Explain what happens to the pitch of the sound heard by the observer in (b)(i) above when the observer moves faster than the source (2)

(c) (i) A star which emits light of wavelength λ is approaching the earth with velocity v. If the velocity of light is c, write down an expression for the shift in the wavelength of the emitted light. (1)

(ii) Describe how the speed of a star may be measured using the Doppler effect.
(4)

(d) Two open pipes of lengths 78 cm and 80 cm are found to give a beat frequency of 5 Hz when each is sounding in its fundamental note. If the end errors are 1.7 cm and 1.5 cm respectively, calculate the;

(i) velocity of sound in air (4)

(ii) frequency of each note. (2)

4(a) (i) What evidence does suggest that light is a transverse wave while sound is a longitudinal one? (1)

(ii) What is meant by ***division of wave fronts*** as applied to interference of waves?
(2)

(b) Two slits X and Y are separated by a distance s and illuminated with light of wavelength, λ. Derive the expression for the separation between successive fringes on a screen placed a distance D from the slit. (5)

(c) A source of light, a slit, S, and a double slit (A and B) are arranged as shown below

(i) Describe what is observed on the screen through the microscope when a white source of light is used. (2)

(ii) Explain what is observed when slit S is gradually widened. (3)

(iii) How would you use the set up above to measure the wavelength of red light?
(4)

(d) In Young's double-slit experiment, the 8th bright fringe is formed 6mm away from the centre of the fringe system when the wavelength of light used is 6.3 x 10^{-7} m. Calculate the distance of the screen from the slits if the separation of the two slits is 0.7 mm.
(3)

5(a) (i) Define wave length and phase difference. (2)

(ii) Using straight wave fronts, explain why a convex lens converges light passing through it. (2)

(b) The speed of sound in a medium is given by

Speed = $\sqrt{\frac{\text{elastic modulus of a medium}}{\text{density of the medium}}}$. Use the expression to explain the effect of humidity on the speed of sound in air. (2)

(c) A wire of diameter 0.04 cm and made of steel of density 8000 kgm^{-3} is under constant tension of 80 N. When a fixed length of 50 cm is plucked in the middle, it resonates with an open tube of length 58 cm sounding its fundamental note. Find the;

(i) end correction of the tube. (4)

(ii) frequency of the beats produced with the tube when only 40 cm of the wire is used. (3)

(d) (i)What is Doppler effect? (1)

(ii)An observer O moving along a straight road at a velocity u_0 approaches a source of sound S moving in the opposite direction at a velocity u_S. Suppose f is the frequency of the sound waves and v is the speed of sound waves in air, derive an expression for the apparent frequency of waves received by the observer. (3)

(iii) Describe the application of Doppler effect in the measurement of the speed of a star relative to the earth. (3)

6(a) (i) State Huygens' principle. (1)

(ii) Use Huygens' principle to verify Snell's law of refraction. (4)

(b)

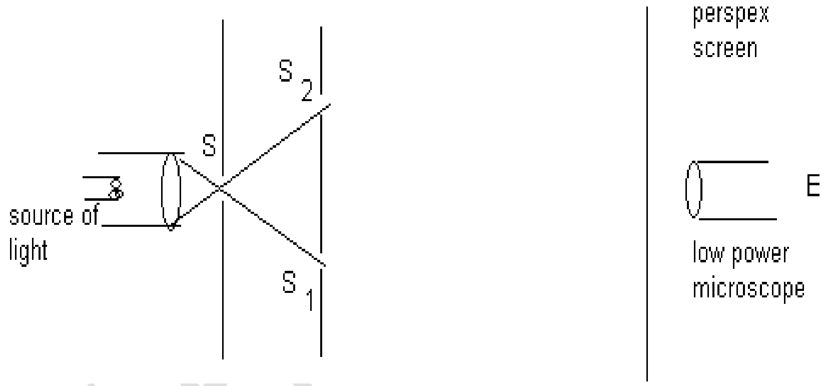


Fig. 1

The set up in figure 1 is used to produce interference patterns on a Perspex screen. Describe how you would use the above set up to compare the wave lengths of green and red lights. (4)

Explain what would be observed when the double slits S_1 and S_2 are moved farther away from the primary slit S. (2)

(c) Two optically thin, flat glass slides are separated at one end by a wire of diameter 0.20 mm. At the other end, the slides touch each other, giving the air between them a thickness ranging from 0 to 0.20 mm. The plates are 15.0 cm long and are illuminated from above by light of wave length 6.0×10^{-7} m.

(i) Use suitable well defined symbols to derive an expression for the fringe separation observed in the air – wedge. (4)

(ii) Determine the number of bright fringes seen in the reflected light. (3)

(iii) What is the effect of increasing the thickness of the sheet separating the glass slides and using light of longer wave length, on fringe separation. (2)

SECTION C (A.C circuits and MAGNETISM)

1(a) Define the following terms as applied to voltage in alternating current circuits.

(i) ***Root-mean-square value***. (1)

(ii) ***Peak value***. (1)

(b) Derive the relationship between the root mean square value and the peak value of the alternating current. (4)

(c) With the aid of a labeled diagram, describe the mode of operation of a repulsion type moving iron ammeter. (5)

(d) A source of alternating current voltage of ***frequency f*** is connected across the ends of a pure inductor of ***self -inductance L***. Derive an expression for the inductive reactance of the circuit and explain the phase difference between the voltage and the current that flows. (5)

(e) A pure inductor of inductance 2H, is connected in series with a resistor of 500 Ω across a source of e.m.f 240 $V_{(r.m.s)}$, alternating at a frequency of 50 Hz. Calculate the potential difference across the resistor. (4)

2 (a) (i) Give two advantages of alternating current over direct current in power transmission. (2)

(ii) Explain the fact that an alternating current continues to pass through a capacitor whereas direct current cannot. (4)

(b) A sinusoidal voltage, $V = V_o \sin 2\pi ft$, is connected across a capacitor of capacitance, C. Derive an expression for the reactance of the capacitor. (4)

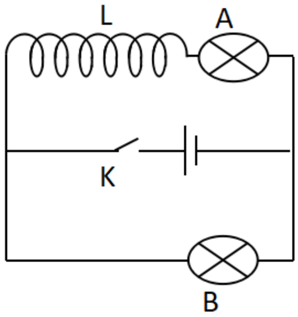
(c) With the aid of a labelled diagram describe the structure and action of a hot- wire ammeter. (6)

(d) Power of 60 kW produced at 120 V is to be transmitted over a distance of 2 km through cables of resistance 0.2 Ω m^{-1}. Determine the voltage at the output of an ideal transformer needed to transmit the power so that only 6% of it is lost. (4)

3(a) Distinguish between reactance and resistance. (2)

(b) An alternating voltage $\mathbf{V = V_o \sin 2 \pi f t}$ is applied to a pure inductor of self-inductance, **L**. Derive an expression for the reactance of the inductor in terms of **f and L**. (4)

(c) Two identical bulbs **A and B** are connected to a coil, **L**, of negligible resistance as shown in the diagram in **figure 3**.



Explain the observations when the switch;

(i) K is closed. (2)

(ii) K is opened. (2)

(iii) Soft iron rod is inserted in the coil and K closed. (2)

(d) A capacitance of **12.5 μF** and resistance **10 Ω** in series with a **20 Ω** resistor is connected to an alternating voltage, **V = (20√2) cos 2000 t, volts**. Find:

(i) the power dissipated in the circuit. (4)

(ii) the potential difference across the capacitor. (2)

(iii) the phase angle between the current and the applied voltage. (2)

4(a) (i) Define the terms impedance and root-mean-square value of an alternating current. (2)

(ii) With the aid of a well labeled diagram, describe the mode of operation of a repulsion type of moving -iron meter. (5)

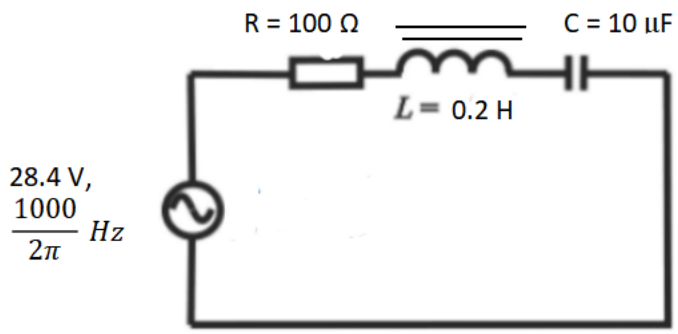
(b) A coil of self-inductance, **L** and negligible resistance is connected across a source of alternating voltage $\boldsymbol{V = V_o \cos \omega t}$.

(i) Find the expression for the current which flows in the coil. (3)

(ii) Sketch, using the same axes, the time variation of the applied voltage and the current which flows in the coil. (1)

(iii) Sketch the vector diagram of the inductor above. (1)

(c)



A series R-L-C circuit is set up as shown in above. Calculate for the circuit;

(i) The root-mean-square current. (4)

(ii) Resonant frequency and state its application. (3)

(iii) Power dissipated in the circuit. (1)

Q5

(a) (i) Distinguish between resistance and reactance.

(ii) Draw a circuit of a full-wave rectifier being used to drive current through a resistor and explain its mode of action.

(b) (i) Define the term magnetic flux.

(ii) A wheel with metal spokes is turning through a steady 2 revolutions per second and it has a radius of 50cm. Its plane is perpendicular to the horizontal component of the earth's magnetic field which is $1.6 \times 10^5 T$. Calculate induced emf in a spoke.

(c) (i) Define frequency of a.c.

(ii) A sinusoidal voltage has a peak valve of 30V at a time of one- tenth of a cycle after a peak has been reached. What current will be present at this instant if the total resistance of the circuit is 9.0Ω?

(d) A coil of self-inductance L and negligible resistance is connected across a source of alternating voltage $V = V_0\ coswt$

(i) Find the expression for the current which flows in the coil.

(ii) Explain why current and voltage are out of phase.

Q6

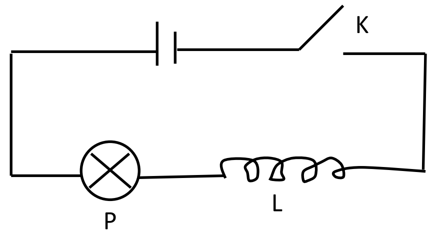
(a) State the laws of electromagnetic induction.

(b) (i) Define mutual inductance.

(ii) Describe an experiment to demonstrate mutual induction.

(c) (i) Define the terms resonant frequency and impedance.

(ii)



A bulb P and an inductor L are connected across a voltage source as shown. Explain what is observed when the switch K is closed and then opened after some time.

(d) A circuit coil of 12 turns carrying a current of 0.8A is placed with its plane in the magnetic meridian. A small magnetic needle placed at the centre of the coil makes 30 oscillations per minute about the vertical axis. When the current is cut off, it makes 20 oscillations per minute. If the horizontal component of the earth's magnetic flux density is $2.5 \times 10^{-5}T$, calculate radius of the coil.

(Assume the square of frequency of oscillations is proportional to magnetic flux density)

(e) With the aid of a diagram, describe the working of an ampere balance.

Q7

(a) (i) Define a tesla.

(ii) With the aid of a diagram, explain the term hall voltage.

(b) (i) Define a Weber.

(ii) A copper wire of length 7.8s is mound into a circuit coil of radius 6cm. A current of 2.5A is passed through the coil.

Calculate the magnetic flux density at the centre of the coil.

(c) (i) Explain the factors which affect the efficiency of a transformer.

(ii) Explain the effect of a fall in supply frequency of current in the primary coil on voltage across the secondary coil of a transformer.

(d) Power of 5000W produced at 90V is to be transmitted over a distance of 3km through cables of resistance$0.4\Omega m^{-1}$.

Find the voltage at the output of a transformer needed to transmit the power so that only 8% of it is lost. (Assume the transformer is 100% efficient).

Q8

(a) (i) State Lenz's law.

(ii) Describe an experiment to demonstrate Lenz's law.

(iii)

The diagram above shows a metal rod PQ, of length 8.0cm being moved in the plane of the paper at $3.0ms^{-1}$ through a magnetic field of flux density $4.0 \times 10^{-2}T$ which is directed into the paper. Find the magnitude of the induced emf in the rod.

(b) (i) Define a magnetic field line.

(ii) Two long parallel wires, 5cm apart are carrying currents of 2A and 4A in opposite directions, in a vacuum.
Find the resultant magnetic flux density at a point midway between the wires.

(c) (i) A rectangular coil of 110 turns is suspended in a uniform magnetic field with the plane of the coil parallel to the field. If a current of $60\mu A$ through the coil causes a deflection of 30^0, calculate the magnetic flux density if the torsional constant of the suspension is $2.5 \times 10^{-8}Nm$ per degree.

(ii) Explain the necessary modification made on the ballistic galvanometer to convert it into a moving coil galvanometer.

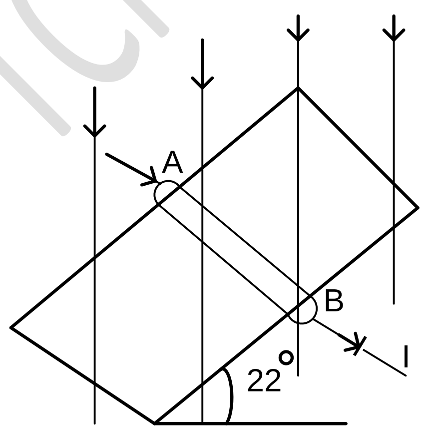
Q9

(a) Define an ampere.

(b) Explain how the definition in (a) above is used in the measurement of current

(c)(i) Explain why a current carrying conductor placed in a magnetic field experiences a force.

(ii) A Metal rod AB of mass 40g and 20cm long is placed parallel to a frictionless plane inclined at an angle of 20^0 to the horizontal, the rod carries a current in the direction AB as shown



If the plane lies in uniform magnetic field of flux density 0.25T, calculate the current in the rod such that it remains stationary.

(d)(i). with the aid of a well labelled diagram, describe the structure and mode of operation of a moving coil galvanometer.

(ii), explain the structural modifications to convert a moving coil galvanometer to ballistic galvanometer.

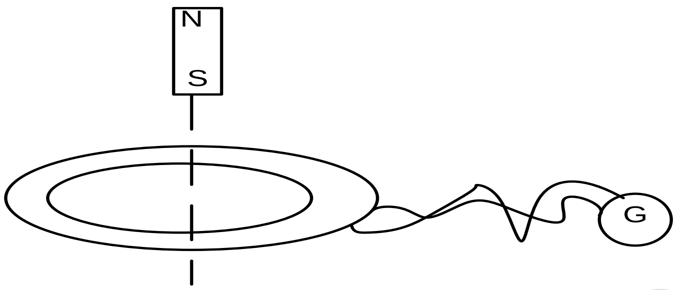
Q10

(a) (i). Explain what is meant by Hall Effect and give any two instances where it's applied.

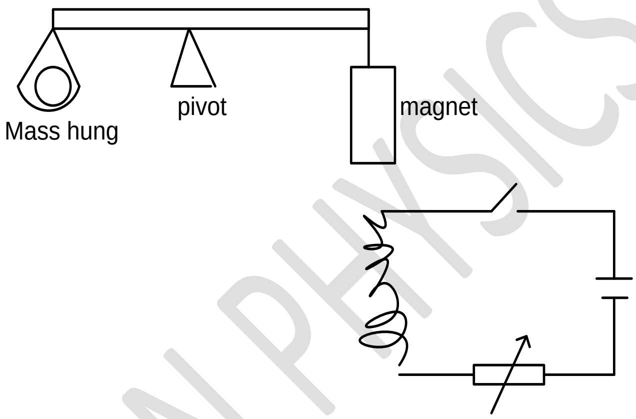
(ii). A circular coil of 20 turns each of radius 10cm and lies on a flat table. The earth's magnetic field intensity at the location of the coil is $43.8Am^{-1}$ while the angle of dip is 67^0, find the magnetic flux threading the coil.

(b) Describe an experiment to determine the angle of dip using an earth inductor

(c) A circular coil of many turns is fixed with its plane horizontal as shown below.



The ends of the coil are connected to a center zero galvanometer G. a magnet is released from rest so that it falls vertically through the coil. Sketch a graph of deflection of the galvanometer against time of fall of the magnet and explain the main characteristics of the graph



The fig above represents a current balance. When switch is open, the force required to balance the magnet is 0.2N. When the switch is closed and a current of 0.5A flows, a force of 0.22N is required for balance.

i. Determine the polarity of the magnet closest to the coil.

ii. Calculate the force required for balance when a current of 2A flows in the coil

Q11

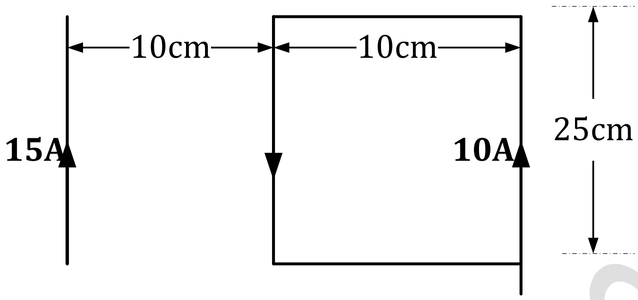
(a) (i) Define the term magnetic flux and state its SI unit.

(ii) A coil of 10 turns and mean radius 5.0 cm lies with its plane on a flat horizontal table. The plane of the coil is threaded by a magnetic field of 0.85 T making an angle of 60° with the horizontal. Calculate the magnetic flux linking the coil.

(b) (i) Two parallel wires each of length, **L**, carry currents of the same

Magnitude, **I**, in opposite directions in free space. The two wires are separated by a distance, **d**. Derive an expression for the magnetic force exerted on any one of the wires.

(ii) A rectangular loop of size 25cm by 10cm carries a current of 10A but with its longer side parallel to the straight wire 10cm apart carrying a current of 15A as shown below.



Calculate the resultant force on the loop

(c) Describe an experiment to accurately measure resistance.

(d) Give four industrial applications of magnets.

SECTION D

1(a) (i) State Coulomb's law of electrostatics.

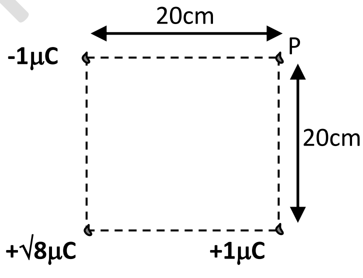
(ii) Define the terms ***electric field intensity*** and ***electric potential at a point***.

(b) (i) Sketch graphs of the variation of electric potential and electric field intensity with distance from the centre of a charged conducting sphere.

(ii) Describe how a conducting body may be positively charged but remains at zero potential.

(iii) Explain how the presence of a neutral conductor near a charged conducting sphere may reduce the potential of the sphere.

(d) Charges of **-1μC**, **+√8μC** and **+1μC** are placed at the corners of a square of side 20 cm as shown below;



Calculate the:

(i) electric potential at P

(ii) electric field intensity at P

2(a) Define the terms

(i) Dielectric constant

(ii) Equipotential

(b) (i) State the characteristics of an equipotential.

(ii) Explain the occurrence of corona discharge

(c) Describe, with the aid of a diagram, how a high voltage can be generated using a Van der Graaf generator.

(d) An air capacitor of capacitance 600 μF is charged to 150 V and then connected across an uncharged capacitor of capacitance 900 μF.

(i) Find the energy stored in the 900 μF capacitor

(ii) With the two capacitors still connected, a dielectric of dielectric constant 1.5 is inserted between the plates of the 600 μF capacitor. Find the new p.d. across the two capacitors.

3.(a) A battery of emf E volts and internal resistance 5 Ω is connected in series with aresistor of variable resistance R.

Find the condition for the maximum power dissipated in the variable resistance.

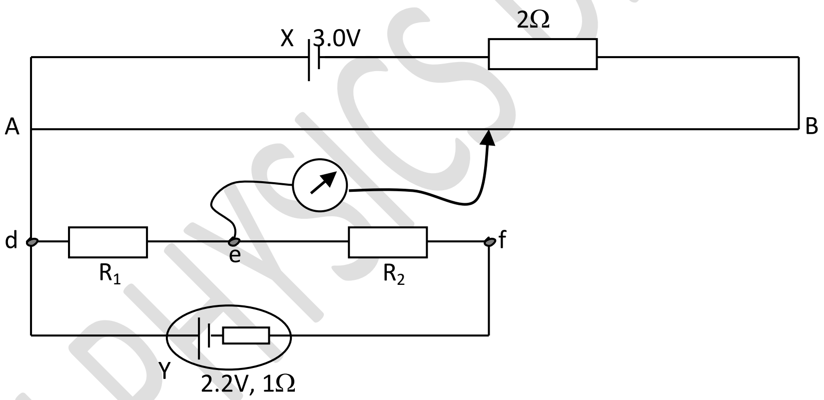
(b) A d.c source of emf 22 V and negligible internal resistance is connected in series with two resistors of 500 and R ohms, respectively. When a voltmeter is connected across the 500 Ω resistor, it reads 10 V while it reads 8 V when connected across the resistor of R ohms. Find the:

(i) resistance of the voltmeter

(ii) value of R

(c) Describe how you would use a slide wire potentiometer to measure the internal resistance of a dry cell.

(d) In the circuit diagram shown below, AB is a slide wire of length 1.0 m and resistance 10 Ω. X is a driver cell of emf 3.0 V and negligible internal resistance. Y is a cell of emf 2.2 V and internal resistance 1.0Ω



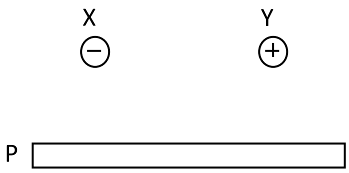
When the centre-zero galvanometer is connected in turns to points **e** and **f**, the balance lengths obtained are 45.0 cm and 80.0 cm respectively. Calculate the:

(i) current flowing through R_1.

(ii) resistances of R_1 and R_2.

4 (a) (i) Explain why a neutral conductor may be attracted to a charged body.

(ii) X and Y are small neighbouring balls charged as shown in the figure below and brought near a positively charged plate P.

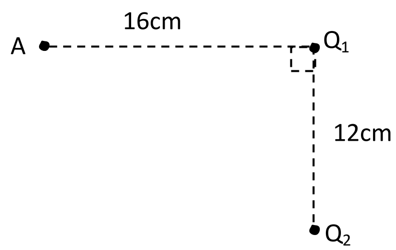


Sketch the electric field pattern in the region of the three bodies and indicate the neutral point(s).

(b) Describe an experiment to investigate the charge distribution over the surface of a charged conductor.

(c) Derive an expression for the electric potential at a point which is a distance r from an isolated point charge Q in a medium of permittivity □.

(d) In the figure A is a point 16 cm from a point charge Q_1.



Another point charge Q_2 is located 12 cm from Q_1 as shown. If Q_1□□□□□□C and Q_2 = 6 □C, find the work done in moving a charge of 2 □C from point A to a point midway between A and Q_2.

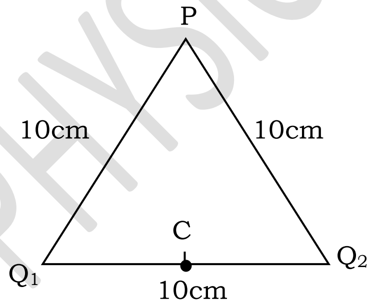
5(a) (i) Explain why a charged body attracts a neutral conductor.

(ii) Explain the occurrence of corona discharge.

(b) Describe an experiment to investigate the charge distribution over a conductor, showing how the conclusion is arrived at.

(c) (i) Derive an expression for the electric potential at a point a distance d from a point charge Q in a medium of permittivity ε.

(ii) The diagram below shows two point charges Q_1 and Q_2 of +6μC and +4μC respectively



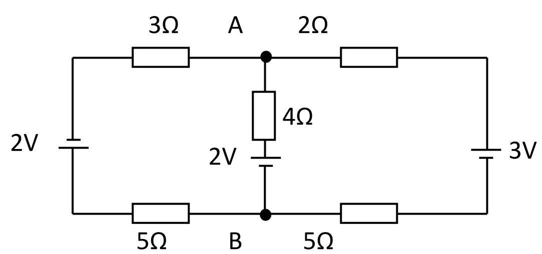
Find the work done in moving a charge of **– 4 μC** from point P to point C midway between Q_1 and Q_2 and interpret the answer you have obtained.

6 (a) (i) What is meant by ***potential difference***?

(ii) Define a ***volt***.

(b) Explain why the terminal p.d across a source decreases as a bigger current is drawn from the source.

(c)



In the circuit shown above, find

(i) the current flowing in the 4-ohm resistor.

(ii) the p.d between points A and B.

(d) Describe an experiment to measure the internal resistance of a cell.

(e) When a battery of emf 2 V is connected in series with a cell C, the combination gives a balance length of 80.0 cm. When cell C is reversed, the balance length falls to 16.0 cm. What is the emf of cell C?

7(a) (i) What is meant by the dielectric constant?

(ii) Derive an expression for the energy stored in a capacitor, of capacitance C, charged to a voltage V.

(b) Explain the action of a dielectric.

(c) Describe how the unknown capacitance of a capacitor can be determined using a ballistic galvanometer.

(d)A capacitor of capacitance 5 μF is charged to a p.d. of 52 V with the aid of a battery. The battery is then removed and the capacitor is connected to an uncharged capacitor of capacitance 8μF. Calculate:

(i) the final p.d., V across the combination.

(ii) the energy stored before and after connecting the two capacitors.

(iii) Account for the difference in the quantities of energy calculated.

8(a) (i) State Ohm's law

(ii) Describe an experiment to verify Ohm's law.

(b) An accumulator of emf 3V and negligible internal resistance is joined in series with a resistance of 500 Ω and another resistance of 300 Ω. The voltmeter reads $\frac{5}{3}$ V when connected across the 500 Ω resistor. Calculate;

(i) the resistance of the voltmeter.

(ii) the reading of the voltmeter when connected across the 300 Ω resistor.

(c) Define

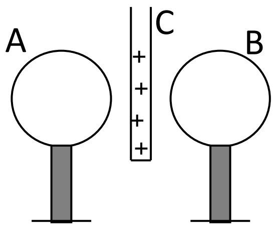
(i) ***electrical resistivity***

(ii) ***temperature coefficient of resistance***

(d) An electric element consists of 4.64 m of nichrome wire of diameter 0.5 mm, the resistivity of nichrome at 15^oC being 1.12 x 10^{-6} Ωm. When connected to a 240V supply, the fire dissipates 2.0 kW and the temperature of the element is 1015^oC. Determine the mean temperature coefficient of resistance of nichrome between 15^oC and 1015^oC.

10(a) Explain how objects get charged by rubbing.

(b) The diagram shows two metallic spheres A and B placed apart and each supported on an insulating stand. A positively charged plate C is placed mid-way between them but without touching them.



B is momentarily earthed in the presence of C. Finally C is withdrawn.

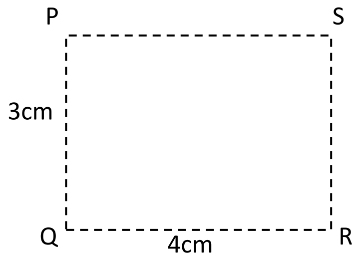
(i) Draw the spheres at the end of the operation and show the charge distribution over them.

(ii) On the same diagram sketch the electric field pattern in the region of the spheres.

(iii) Explain the change in p.d between the spheres as the spheres are moved further apart.

(c)Describe an experiment to show that excess charge resides outside a hollow conductor.

(d) Charges of **-3μC**, **+4μC** and **+3μC** are placed at the corners P, Q and R of a rectangular frame PQRS in which PQ = 3 cm and QR = 4 cm as shown in the figure below



If the charges are in vacuum, calculate the magnitude of the electric intensity at S due to the charges.

11(a) Define

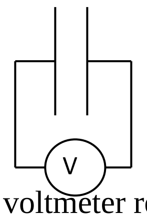
(i) ***capacitance***

(ii) ***dielectric strength***

(b) Describe an experiment to show the relationship between capacitor charge and potential difference.

(c) Derive an expression for the equivalent capacitance of three capacitors connected in series.

(d)Two large metal plates, placed parallel to each other and separated by dry air, form a capacitor. The arrangement is given a charge, then isolated and finally an ideal voltmeter is connected across its plates as shown.



Explain what is observed on the voltmeter reading when

(i) an insulating material is inserted in between the plates.

(ii) the separation of the plates is increased.

(e) When two capacitors, C_1 and C_2 are connected in series and the combination connected to a supply V the charge stored by C_1 is 8μC while the p.d. across C_1 is 4V. When the capacitors are connected in parallel to the same supply the total charge stored by the combination is 36μC. Given that $C_1 < C_2$, find;

(i) the capacitances of the capacitors

(ii) the p.d, V, of the supply