KING'S COLLEGE, BUDO

PHYSICS REVISION QUESTIONS – RECESS 2020 PAPER 2 QUESTIONS

SECTION A (Geometrical Optics - Light)

1(a) For a converging mirror define the terms

(i) radius of curvature (1)

(ii) principal focus (1)

(b) With the aid of a ray diagram derive the mirror formula for a convex mirror. (6)

(c) (i) With the aid of a ray diagram, describe the structure and action of a reflecting telescope in normal adjustment. (5)

(ii) State two advantages of a reflecting telescope over a refracting one. (2)

(d) An astronomical telescope with an objective of focal length 84.0 cm and an eyepiece of focal length 8.0 cm. The eyepiece is shifted until the final image is formed at a distance of 64.0 cm from the objective. Find the distance between the two lenses. (5)

2(a) (i) Explain the difference between the terms **magnifying power** and **magnification** as applied to optical instruments. (3)

(ii) State what is meant by **normal adjustment** in the case of an astronomical telescope. (1)

(iii) With the aid of a ray diagram, explain how the two lenses of a telescope form, at infinity, a magnified virtual image of a real distant object. (4)

(b) A telescope has an objective of focal length 80cm and an eyepiece of focal length 2.0cm. It is focused on the moon, whose diameter subtends an angle of 8.0×10^{-3} rad at the objective. The eyepiece is adjusted so as to project a sharp image of the moon onto a screen placed 20cm from the eyepiece lens. Calculate:

(i) the diameter of the intermediate image formed by the objective lens. (3)

(ii) the diameter of the image on the screen. (3)

(iii) the separation of the lenses. (2)

(c) Explain, with the aid of a diagram, the formation of the **eye-ring** in a telescope and state why it is the best position for the eye of the observer. (4)

3(a) (i) What is meant by ***refraction of light***? (1)

(ii) Explain why a pond of clear water appears shallower, than it actually is, to an observer. (3)

(iii) Describe an experiment to determine the refractive index of a liquid using the air-cell method. (6)

(b) A lens forms a sharp image of height h_1 on a fixed screen. As the lens is moved towards the screen another sharp image of height h_2, of the same object, is formed on the screen. If the object position remained the same in both cases, obtain an expression for the height of the object. (4)

(c) A converging lens of focal length 30 cm is placed between an object and a diverging lens of focal length 5 cm. If the object is 6 metres from the converging lens and 6.20 metres from the diverging lens, determine

(i) the position and nature of the image formed. (4)

(ii) the magnification of the image. (2)

4(a) (i) Define ***absolute refractive index*** of a material. (1)

(ii) Explain, with the aid of a diagram, why a thick plane mirror forms multiple images. (4)

(b) Describe how the refractive index of a liquid can be determined using a concave mirror. (6)

(c) (i) A parallel-sided glass block of thickness h and refractive index n is placed over a mark scribbled on a sheet of paper. Write an expression for the apparent displacement of a mark when viewed directly from above. (1)

(ii) A coin is placed at the bottom of a beaker. Water of refractive index 1.33 is poured in the beaker to a height of 15 cm. Above the water surface there is a layer of another liquid L, of thickness 8 cm. An observer from above sees the coin displaced 6.0 cm from the bottom. Calculate the refractive index of the liquid. (3)

(d) (i) For a ray of light passing through a prism perpendicular to the refracting edge of the prism, what are the conditions for minimum deviation? (1)

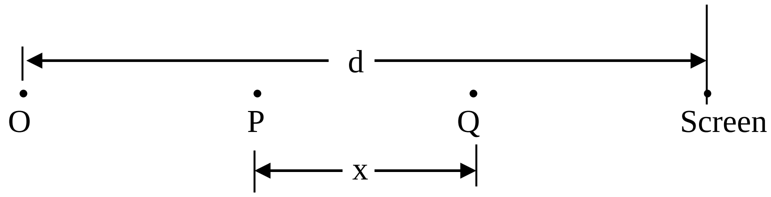
(ii) In part (i), if the refracting angle of the prism is □, the minimum deviation is □, and the refractive index of the material of the prism is n, derive an expression relating n, □ and □. (4)

5(a) What is meant by the following?

(i) ***Conjugate points*** with respect to a lens. (1)

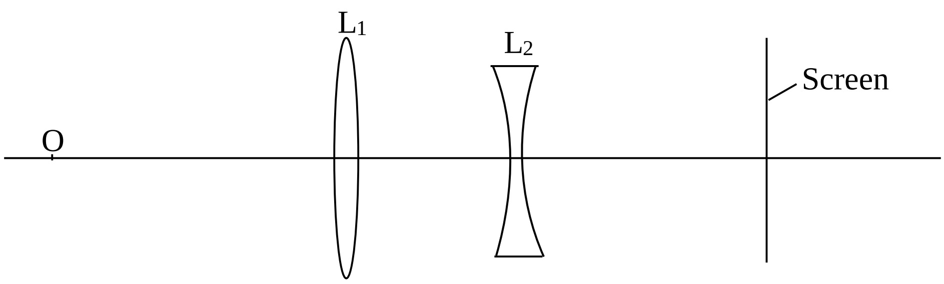
(ii) ***A real image*** (1)

(iii) In the diagram below the image of the object is formed on the screen, which is d cm from the object O, when a convex lens is placed either at P or Q.



If P and Q are x cm apart, find an expression for the focal length of the lens in terms of d and x. (3)

(b) A convex lens, L_1, and a concave lens, L_2, of focal lengths 20 and 10 cm respectively are mounted coaxially apart with the convex lens facing an object, O, 40 cm away.



The arrangement casts a sharp image of O onto a screen which is 30 cm from L_2.

(i) Calculate the distance between the two lenses. (5)

(ii) If now the screen is withdrawn and L_2 is shifted until the final image is virtual and 30 cm from L_2, find the new distance between L_1 and L_2. (3)

(c) (i) Draw a labelled diagram to show how two converging lenses can be used to make a compound microscope in normal adjustment. (2)

(ii) An object of size 2.0 mm is placed 2.5 cm in form of the objective of a compound microscope. The focal length of the objective is 2.2 cm while that of the eyepiece is 5.0 cm. The microscope forms a virtual image of the object at the near point (25 cm) from the eye. Find the size of the final image. (5)

6(a) (i) State the laws of reflection of light. (2)
(ii) With the aid of a ray diagram show that the image formed by a plane mirror is the same size as the object. (4)

(b) Derive the mirror formula for a concave spherical mirror. (5)

(c) Describe an experiment to determine the focal length of a convex mirror using a plane mirror. (5)

(d) A concave lens is placed coaxially in front of a concave mirror of focal length 12 cm. An object, placed 34 cm from the mirror, coincides with its own image when the lens is 14 cm from the mirror. Find the focal length of the lens. (4)

7(a) In light what is meant by
(i) Refraction
(1)
(ii) Critical angle (1)

(b) Explain why a pond of clear water looks shallower than it actually is. (3)

(c) A lens is set up and produces an image of luminous point source on a screen 25 cm away. Then a parallel glass slab of thickness 6 cm and refractive index 1.6 is placed between the lens and the screen. If the aperture of the lens is small
(i) sketch a ray diagram to show how the image is formed on the screen in the latter arrangement (3)
(ii) find by how much the screen must be shifted from its original position so as to cast a clear image. (4)

(d) (i) With the aid of a ray diagram explain how a Galilean telescope forms an image at the near point. (4)
(ii) Derive an expression for the angular magnification of the arrangement described in (d)(i) (4)

8(a) (i) State the laws of reflection. (2)

(ii) Give a case where spherical mirrors are more convenient to use than plane mirrors and briefly explain why they are more convenient. (2)

(iii) Explain why parabolic mirrors instead of spherical ones are employed in reflecting telescopes. (2)

(b) (i) Draw a ray diagram to show how a **diverging mirror** forms an image. (2)

(ii) Describe an experiment to determine the focal length of a diverging mirror by the use of a converging lens. (5)

(c) A concave mirror forms, on a screen, a real image of **half** the linear dimensions of the object. The object and the screen are then moved until the image is **three times** the size of the object. If the shift of the screen is 25 cm, determine

(i) the focal length of the mirror (4)

(ii) the shift of the object (3)

9(a) (i) State the conditions for total internal reflection. (2)

(ii) Draw a labeled diagram of a named device to show (without description) an application of total internal reflection. (2)

(b) Explain how a fish in a pond is able to enjoy a 180° field of view. (3)

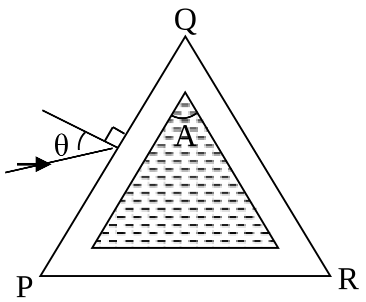
(c) Show that when a ray of light passes through different media separated by plane boundaries

$$n \sin i = \text{constant}$$

where ***n*** is the absolute refractive index of a medium and ***i*** is the angle made by the ray with the normal in the medium. (4)

(d) Describe an experiment to measure the refractive index of glass of rectangular shape, using a pin, by the apparent depth method. (4)

(e) The figure below shows a liquid of refractive index 1.33 enclosed by glass of uniform thickness. A ray of light, incident on face PQ at an angle of incidence, θ, emerges through face QR.



As the angle θ is reduced, suddenly the emergent ray disappears when
θ = 16°.Find the angle A. (5)

10 (a) What is meant by
(i) visual angle (1)
(ii) magnifying power of an optical instrument (1)
(iii) chromatic aberration (1)

(b) Describe how a pure spectrum may be obtained. (4)

(c) (i) With the aid of a ray diagram, explain how the two lenses of a telescope form, at infinity, a magnified virtual image of a real distant object.
(4)

(ii) Derive an expression for the magnifying power of the arrangement in (b)(i) (2)

(d) A telescope with an objective of focal length 50 cm and an eyepiece of focal length 8 cm forms the final image of a distant object at a point 30 cm from the eyepiece. In this adjustment, find

(i) the length of the telescope (4)

(ii) the angular magnification
(3) 11(a) (i) State how **spherical** aberration and **chromatic** aberration is minimised in lens instruments. (2) (ii) Explain why the virtual image seen in a magnifying glass is almost free of chromatic aberration when the eye is placed close to the lens. (2)

(b) State
(i) the advantages of a reflector telescope over a refractor telescope. (2)

(ii) how the resolving power of a reflector telescope can be increased. (1)

(c) (i) With the aid of a ray diagram, describe how a compound microscope may be used to form at infinity the image of an object. (4)

(ii) Derive an expression for the magnifying power of the microscope in c(i). (3)

(iii) If the final image formed coincides with the object, and is at the least distance of distinct vision (25cm) when the object is 3 cm from the objective, calculate the focal lengths of the objective and the eye lenses, given that the magnifying power of the microscope is 15. (6)

SECTION B (Physical Optics – Waves)

1(a) (i) Distinguish between **free** and **damped** oscillations. (2)

(ii) What is a **wave**? (1)

(b) A mechanical wave in a certain medium is represented by the equation

$y = 0.3\sin 2\pi(35t - 0.4x)$ where all distances are in metres.

(i) State what each of the symbols x and y represents. (2)

(ii) Find the velocity of the wave (3)

(c) (i) What is meant by **resonance** in waves? (1)

(ii) Describe an experiment to determine the velocity of sound in air using the resonance method. (6)

(d) (i) What is a **harmonic** in sound. (1)

(ii) A string of length 0.50 m and mass 5.0 g is stretched between two fixed points. If the tension in the string is 100 N, find the frequency of the second harmonic.

(Velocity of sound along the string $= \sqrt{\left(\frac{\text{Tension}}{\text{Mass per unit length}}\right)}$) (4)

2(a) Distinguish between progressive and stationary waves. (4)

(b) A string under tension has a number of natural frequencies. Briefly describe an experiment to show that such a string vibrates freely only at its natural frequencies.(5) (c) A uniform wire of length 1.00m and mass 2.0 x 10^{-2} kg is stretched between two fixed points. The tension in the wire is 200N. The wire is plucked in the middle and released. Calculate the:

(i) speed of the transverse waves. (2)

(ii) frequency of the fundamental note. (3)

(d) (i) Explain how beats are formed. (3)

(ii) Derive an expression for the beat frequency. (3)

3(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)

4(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)

5(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 wavefronts*** 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)

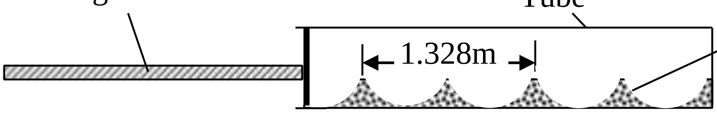
(iii) How would you use the set up above to measure the wavelength of red light? (4)

(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)

6(a) (i) State **two** characteristics of a stationary wave. (2)

(ii) What is meant by ***Doppler effect***? (1)

(b) In an experiment to determine the speed of sound in air in a tube, chalk dust settled in heaps as shown in the figure below



If the frequency of the vibrating rod is 252 Hz and the distance between three consecutive heaps is 1.328 m, calculate the speed of sound in air. (3)

(c) The speed of sound in air is given by $\mathbf{v} = \sqrt{\frac{\gamma \mathbf{P}}{\boldsymbol{\delta}}}$,

where P is the pressure, δ the density and the ratio of the principal heat capacities of air. Use this expression to explain the effect of temperature on the speed of sound in air. (3)

(d) (i) A train moving with uniform velocity, v_1, sounds a horn as it passes a stationary observer. Derive the expression for the apparent frequency of the sound detected by the observer. (3)

(ii) If the frequency of the sound detected by the observer after the train passes is 1.2 times lower than the frequency detected when the train is approaching, find the speed of the train. [speed of sound in air = 330 ms^{-1}] (4)

(e) Describe a simple experiment to show interference of longitudinal waves. (4)

7(a) (i) Define the term ***diffraction***. (1)

(ii) What is meant by ***plane polarised light***? (1)

(iii) Explain the term ***path difference*** with reference to interference of two wave motions (3)

(b) (i) Describe how polarized light is produced by double refraction. (5)

(ii) State **two** uses of polarized light. (2)

(iii) A parallel beam of unpolarised light incident on a transparent medium of refractive index 1.62, is reflected as plane polarized light. Calculate the angle of incidence in air and angle of refraction in the medium. (3)

(c) (i) What is a ***diffraction grating***? (1)

(ii) Sodium light of wavelengths 5.890×10^{-7}m and 5.896×10^{-7}m falls normally on a diffraction grating. If in the first order beam, the two sodium lines are separated by 2 minutes, find the spacing of the grating. (4)

8(a) Distinguish between transverse and longitudinal waves. (2)

(b) The displacement Y of a wave traveling in x-direction at a time t is

$Y = a \sin 4\pi(5t - 0.2x)$ meters. Find

(i) the period of the wave. (3)

(ii) the velocity of the wave. (3)

(c) (i) What is meant by Doppler effect? (1)

(ii) A police car moving at 90 km h^{-1}, sounds a siren of 945 Hz as it approaches a stationary observer. What is the apparent frequency of the siren heard by the observer if the speed of sound in air is 335 ms^{-1}.

(3)

(iii) Give one application of the Doppler Effect. (1)

(d) (i) Describe the motion of air in a tube closed at one end and vibrating in its fundamental mode. (3)

(ii) A cylindrical pipe of length 29 cm is closed at one end. The air in the pipe resonates with a tuning fork of frequency 860 Hz sounded near the open end of the tube. If the velocity of sound is 340 ms^{-1}, determine the mode of vibration and find the

end correction. (4)

9(a) What is meant by the term ***stationary wave***? (1)

(b) The displacement, y in metres, in a progressive wave is given by
$y = 0.2\sin 2\pi(12t - 5x)$. Find:
(i) the wavelength (2)

(ii) the speed of the wave (2) (c) If the progressive wave in (b) is reflected back along the same path, show that the resultant is a stationary wave and find the amplitude at an antinode of the stationary wave. (5)

(d) (i) In sound, what is meant by the terms ***beats*** and ***Doppler effect***? (2)

(ii) State two uses of beats. (2)

(e) A source that produces sound is receding from a stationary observer towards a vertical wall with a speed of 4 ms^{-1}. The observer hears beats of frequency 5 Hz.

(i) Explain why the observer hears the beats. (3)

(ii) Find the frequency of the source of sound, if the velocity of sound is 340 ms^{-1}. (3)

SECTION C (Magnetism and A.C circuits)

1(a) What is meant by the terms:

(i) Magnetic meridian (1)

(ii) Magnetic declination (1)

(b) Explain what happens to the angle of dip as one moves along the same longitude from the Equator to the North pole. (2)

(c) (i) Write down an expression for the magnetic flux density at the centre of a narrow circular coil of radius r having N turns when a current I is flowing in it. (1)

(ii) Describe an experiment to determine horizontal component of the Earth's magnetic flux density at a certain location. (5)

(d) A circular coil of 4 turns and diameter 14.0 cm carries a current of 0.35A. It is placed at the equator with its plane along the magnetic meridian. Calculate the direction and magnitude of the resultant magnetic flux density at the position if the earth's magnetic flux density at the location is 1.8 x 10^{-5} T. (4)

(e) (i) What is meant by the term ***magnetic moment*** of a coil? (1)

(ii) Explain why a moving coil galvanometer must have the following:

A radial magnetic field,

Fine hair springs,

Large number of turns

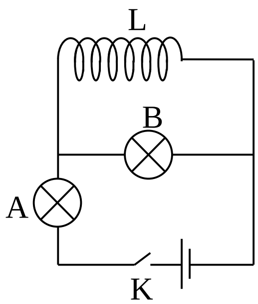
A conducting former. (5)

2(a) What is meant by

(i) self induction (1)

(ii) eddy current (1)

(b) The diagram shows an iron-cored coil, L, of many turns and negligible resistance with identical bulbs, A and B, connected in a circuit.



(i) When switch K is closed, at first both bulbs A and B light up, but soon B dims out while A becomes brighter. Explain these observations. (3)

(ii) If now K is opened, state and explain what is observed. (3)

(c) (i) Explain the origin of the back emf in a motor. (2)

(ii) A motor, whose armature resistance is 2Ω, is operated on 240V mains supply. If it runs at 3000 rev min^{-1} when drawing a current of 5 A, at what speed will it run when drawing a current of 15 A? (3)

(d) (i) With the aid of a labeled diagram, describe the mode of action of a simple d.c generator. (5)

(ii) Sketch the output against time of a simple d.c generator. (1)

(iii) State two factors that determine the polarity of the output of a d.c generator. (1)

3(a) (i) Define the unit of magnetic flux density. (1)

(ii) A rectangular coil of length ***l*** *and breadth* ***b*** *has* **N** turns and carries a current I. It is placed with its plane vertical in a horizontal magnetic field of flux density **B**. Derive an expression for the torque exerted on the coil when the normal to its plane makes an angle **θ** with the magnetic field. (5)

(b) Explain the origin of the force on a current-carrying conductor placed in a magnetic field. (3)

(c) (i) Define the term angle of Dip as applied to the earth's magnetism. (1)

(ii) A circular coil of 4 turns and diameter 11.0 cm carries a current of 0.35A. It is placed with its plane in the magnetic meridian. Calculate the direction and magnitude of the resultant magnetic flux density at a position where the horizontal component of the earth's magnetic flux density is 1.8×10^{-6} T. (5)

(d) Explain why a moving coil galvanometer must have the following:- A radial magnetic field, fine hair springs, large number of turns and a conducting former. (5)

4(a) Explain the meaning of the terms

(i) ***self induction*** (1)

(ii) ***mutual induction***. (1)

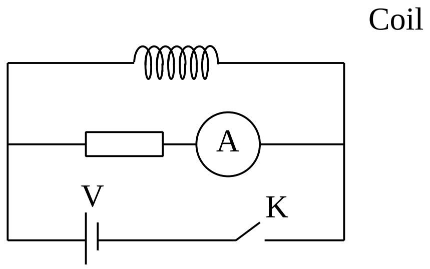
(b) (i) State the laws of electromagnetic induction. (2)

(ii) By using a suitable illustration with a North Pole, explain how Lenz's law serves as a good example of the principle of conservation of energy. (4)

(c) (i) Explain the main energy losses in a transformer and how they can be minimized. (4)

(ii) An a.c. transformer operates on a 240 V mains. The voltage across the secondary is 20 V. If the transformer is 80% efficient, calculate the current in the primary coil when a resistor of 40Ω is connected across the secondary. (3)

(d)



An iron-cored coil is connected as shown in the circuit above. Explain what happens to the reading of the Ammeter, A, when the switch k is

(i) first closed. (3)

(ii) opened. (2)

5 (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)

6(a) (i) What is meant by the ***direction of a magnetic field***? (1)

(ii) State the laws of electromagnetic induction. (2)

(iii) A square coil of side 10 cm has 100 turns. The coil is arranged to rotate at 3000 rev. min^{-1} about a vertical axis perpendicular to the horizontal uniform magnetic field of flux density 0.8 T. The axis of rotation passes through the mid-points of a pair of opposite sides of the coil. Calculate the emf induced in the coil when the plane of the coil makes an angle of 60^o with the field. (4)

(b) (i) With the aid of a labelled diagram, describe how a simple d.c motor works. (5)

(ii) Explain how a back emf comes about in a motor (3)

(c) A d.c motor has an armature resistance of 1.0 ohm and is connected to a 240-V supply. The armature current taken by the motor is 20A. Calculate

(i) the emf generated by the armature (2)

(ii) the power supplied to the armature (1)

(iii) the mechanical power developed by the motor (1)

(iv) the efficiency of the motor (1)

7(a) What is meant by the following?

(i) Self-induction (1)

(ii) Eddy current (1)

(b) (i) State and explain the features of a ballistic galvanometer. (4)

(ii) A coil, connected to a closed circuit, is placed in a magnetic field. Show that when the flux linkage of the coil changes, the charge that circulates in the circuit is independent of the time taken. (4)

(c) Describe an experiment to calibrate a ballistic galvanometer. (4)

(d) A capacitor of capacitance $10\mu F$ is charged to a p.d of 5V and then discharged through a ballistic galvanometer which gives a throw of 24 divisions. The capacitor is disconnected and the ballistic galvanometer is connected across a coil of 20 turns wound tightly round the middle of a solenoid of 1000 turns per metre and diameter 4.0 cm. When the current in the solenoid is reversed, the galvanometer deflects through 10 divisions. If the total resistance of the galvanometer circuit is $12\ \Omega$, find the current in the coil. (6)

8 (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)

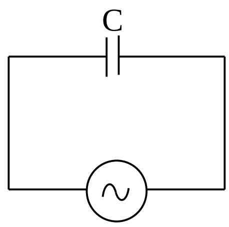
(b) A sinusoidal voltage, $V = V_o \sin 2\pi ft$, is connected across a capacitor of capacitance, C. Derive an expression for the reactance of the capacitor. (4)

(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 $0.2\ \Omega\ m^{-1}$. Determine the voltage at the output of an ideal transformer needed to transmit the power so that only 6% of it is lost. (4)

9(a) Define the term ***impedance*** of an a.c circuit. (1)

(b) In the diagram below, a capacitor is connected across an a.c voltage supply.



(i) Using the same axes, sketch graphs to show the variation of $\mathbf{V_C}$ **and I** with time. (2)

(ii) Explain why current apparently flows through the capacitor. (4)

(c) Describe with the aid of a labeled diagram, the structure and action of **a hot wire ammeter**. (5)

(d) A 250µF capacitor is connected in series with a non-inductive resistor of 20 Ω across a source of p.d $\mathbf{V = 300\sqrt{2}\sin 320t}$. Calculate;

(i) the root mean square (r.m.s) values of the current in the circuit and the p.d across the capacitor. (5)

(ii) the mean rate at which energy is supplied by the source. (1)

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

10(a) (i) Explain why a current-carrying conductor placed in a magnetic field experiences a force. (2)

(ii) Write down the expression for the force on a straight wire of length ***b*** carrying a current **I** at an angle θ to the magnetic field of flux density B. (1)

(iii) A rectangular coil of N turns and area A is suspended in a uniform magnetic field of flux density B. Initially the plane of the coil is parallel to the magnetic field. Derive the expression for the initial torque on the coil when a current I flows through the coil. (3)

(b) (i) Draw a labelled diagram of a moving-coil galvanometer and explain how it works. (6)

(ii) What factors determine the sensitivity of a moving-coil galvanometer? (2)

(c) A small circular coil of 10 turns and mean radius 2.5 cm is mounted at the centre of a long solenoid of 1000 turns per metre with its axis at right angles to the axis of the solenoid. If the current in the solenoid is 2.0 A, calculate the initial torque on the circular coil when the current of 1.0 A passes through it. (5)

11(a) Define the following

(i) magnetic meridian (1)

(ii) magnetic declination (1)

(iii) neutral point in a magnetic field (1)

(b) (i) Sketch the field pattern in a region where a bar magnet is placed east-west in the earth's magnetic field. (3)

(ii) Write down an expression for the flux density at the centre of a narrow circular coil of N turns, radius r carrying a current I. (1)

(c) Describe how you would compare magnetic intensities of two fields using a deflection magnetometer, explaining its principle (6)

(d) A narrow circular coil of 10 turns and diameter 20.0 cm is arranged with its plane in the magnetic meridian. A magnetic compass is placed in a horizontal plane at the centre of the coil. When a current of 7.0 A is passed through the coil, the compass deflects through an angle of 49^o. When the current is reversed, the deflection in the opposite direction is 47^o.

(i) Give a possible reason why the magnitudes of the deflections are different when the current is reversed. (1)

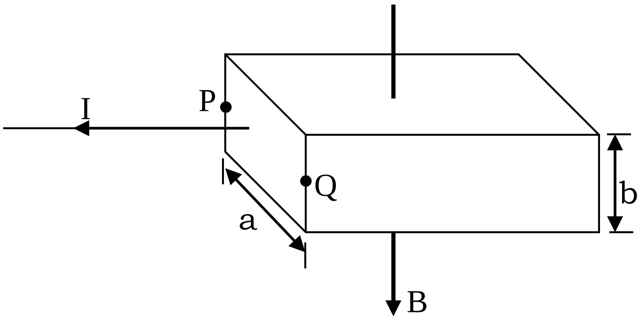
(ii) Calculate the horizontal component of the earth's magnetic flux density. (4)

(iii) What would be the compass deflection if the plane of the coil is perpendicular to the magnetic meridian. (1)

(iv)Give the relationship between the angle of deflection and the radius of the coil. (1)

12 (a) What is a ***magnetic field***? (1)

(b) A magnetic field of flux density B is applied normally to a metal strip carrying current I as shown in the figure below.



(i) Account for the occurrence of a potential difference between points P and Q, indicating the polarity of this p.d. (3)

(ii) Derive an expression for the electric intensity between P and Q if the drift velocity of the conduction electrons is v. (3)

(c) (i) With the aid of a labeled diagram, describe the mode of action of a simple d.c generator. (5)

(ii) Sketch the output against time of a simple d.c generator. (1)

(iii) Explain how a back emf is developed in a motor. (3)

(d) A square coil of side 10 cm has 100turns. The coil is arranged to rotate at 3000 rev. min^{-1} about a vertical axis perpendicular to the horizontal uniform magnetic field of flux density 0.8 T. The axis of rotation passes through the mid-points of a pair of opposite sides of the coil. Calculate the emf induced in the coil when the plane of the coil makes an angle of 60^o with the field. (4)

13(a) State the laws of electromagnetic induction. (2)

(b) A coil of area A is rotated at a frequency f in a uniform magnetic field of flux density B about an axis which is perpendicular to the field.

(i) Derive an expression for the emf generated. (3)

(ii) Deduce at least four of the factors on which the emf depends (2)

(iii) State any two factors that reduce the efficiency of an a.c. generator to less than 100% (2)

(c) A rectangular coil of 50 turns is 15.0 cm wide and 30.0 cm long. If it rotates at a uniform rate of 3000 revolutions per minute about an axis parallel to its long side and at right angles to a uniform magnetic field of flux density 0.04T, find the peak value of the emf induced in the coil. (2)

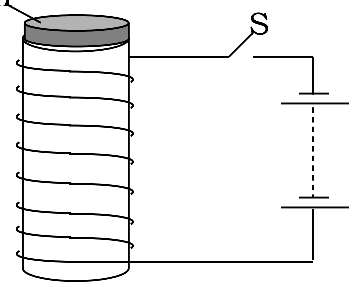
(d) (i) A metallic circular disc of diameter d is in a uniform magnetic field of flux density B and the plane of the disc is perpendicular to the field. If the disc is rotated at a frequency f, derive an expression for the emf developed between its centre and rim. (4)

(ii) Describe an experiment to measure resistance by means of a rotating disc in a magnetic field. (5)

14(a) (i) Distinguish between ***root mean square value*** and ***peak value*** of an alternating current. (2)

(ii) What is the peak value of the voltage from a 220V a.c. mains. (2)

(b) The figure below shows a copper coin resting on a solenoid



Explain these observations:

(i) On closing switch S the coin jumps up and settles back. (3)

(ii) Whenthe d.c. source is replaced bya high-frequency alternating voltage and S is closed, the coin remains in position but gets heated up. (3) (c) (i) What is meant by the term ***capacitive reactance***? (1)

(ii) Derive an expression for the reactance of a capacitor of capacitance C when a sinusoidally varying a.c. of frequency f passes through it. (5)

(iii)A sinusoidal alternating voltage, **V = 10 sin 20t volts,** is applied to a coil of inductance 0.5 H. Assuming that the coil has negligible resistance, calculate the root mean square value of the current. (3)

15 (a) What is meant by each of the following terms?

(i) Flux linkage (1)

(ii) Mutual induction (1)

(b) A coil whose terminals are joined together through a low resistance is placed in a magnetic field. The strength of the field is then changed. Show that the total charge that circulates in the circuit during the period is independent of the time taken. (4)

(c) (i) State and explain the main features of a ballistic galvanometer. (4)

(ii) Describe an experiment you could perform to calibrate a ballistic galvanometer. (4)

(d) A small circular coil of 1000 turns and area 12 cm^2 having total resistance 10Ω is placed coaxially in the middle of a long solenoid of 1000 turns per metre. A ballistic galvanometer of total resistance 10Ω is connected across the terminals of the coil. When the steady current in the solenoid is switched off the ballistic galvanometer gives a maximum deflection of 20 divisions. When the galvanometer is disconnected and a capacitor of capacitance 100 μF charged to 12 V is discharged through it, the galvanometer gives a maximum deflection of 25 divisions.

(i) Describe and explain the behaviour of the pointer of the galvanometer before the steady current is switched off. (2)

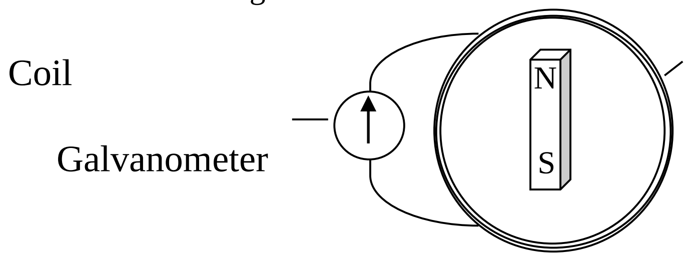
(ii) Determine the steady current through the solenoid. (4)

16(a) (i) State Lenz's laws of electromagnetic induction. (1)

(ii) Describe an experiment to verify Lenz's law. (5)

(b) Derive an expression for the emf induced in a rod which is sweeping across a uniform magnetic field. (4)

(c) In the figure below a bar magnet lies in the plane of a coil whose ends are connected to a galvanometer

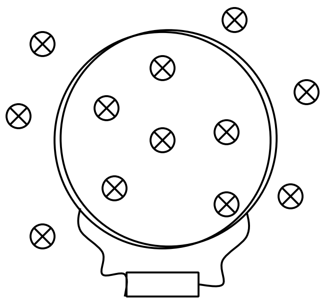


Explain what is observed when each of the following operations is performed:

(i) The magnet is rotated about the axis of the coil. (2)

(ii) The magnet is rotated about an axis which is coplanar with the coil but perpendicular to the length of the magnet. (2)

(d) The diagram below shows a narrow coil of radius 4 cm and 50 turns, placed with its plane normal to a uniform magnetic field B. The ends of the coil are connected across a resistor of 6 .



If the magnetic flux density is increasing at a rate of 50 Ts^{-1}

(i) Re-draw the coil and indicate the direction of the induced current in the coil and explain your answer. (3)

(ii) Find the magnitude of current if the resistance of the coil is 2Ω. (3)

17(a) Define the term ***root-mean-square*** value as applied to an alternating current. (1)

(b) An alternating voltage, of r.m.s value V and frequency f, is connected across a pure capacitor of capacitance C. Derive an expression for the current that flows. (4)

(c) (i) Explain why a moving–coil meter is not suitable for measuring alternating currents. (3)

(ii) With the aid of a labelled diagram, describe the structure and mode of operation of a moving-iron ammeter of the repulsion type. (5)

(d) A sinusoidal alternating voltage **V= 200sin 160t** is applied across a coil of inductance **0.5 H** and resistance **60 .** Find:-

(i) the phase difference between the current and the applied voltage. (2)

(ii) the current through the coil. (3)

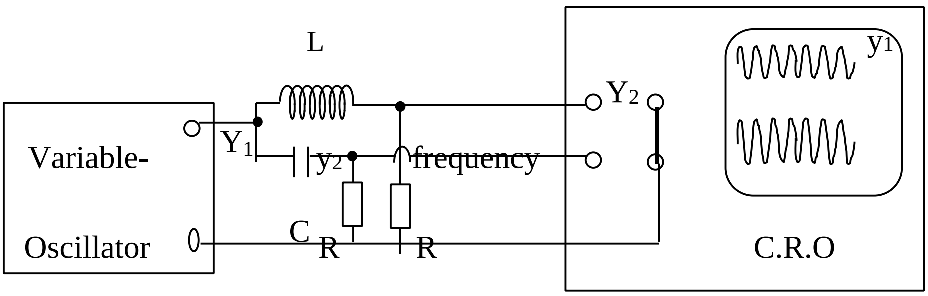
(iii) the power dissipated in the coil. (2)

18(a) (i) The electrical power obtained from a generator is always less than the mechanical power needed to drive the generator. Give reasons why this is so. (2)

(ii) How are the energy losses in a generator minimised? (4)

(b) (i) A capacitor of capacitance C and an inductor of inductance L are each in turn connected across an a.c voltage of frequency f. Write down an expression for the reactance of each of the components. (1)

(ii) An oscillator of variable frequency produces a signal of constant amplitude. The output of such an oscillator is fed into a pair of identical resistors, R, as shown in the diagram.



C is a capacitor and L an inductor. The output through C is connected to the Y_1 plates while that through L is connected to the Y_2 plates of a double-beam C.R.O. y_1 and y_2 are the respective signals due to the inputs at Y_1 and Y_2. It is observed that as the frequency of the oscillator is varied from minimum to maximum the amplitude of y_2 decreases as that of y_1 increases. Explain these observations. (4)

(c) A sinusoidal supply of $40V_{(r.m.s)}$ and frequency 60 Hz is connected across a coil of inductance 1/ H and resistance 160. Determine;

(i) the impedance in the circuit (4)

(ii) the current (r.m.s) that flows (2)

(iii) the average power consumed in the circuit. (3)

SECTION D (Electricity)

1(a) For a source of electricity, what is meant by

(i) electromotive force (1)

(ii) internal resistance? (1)

(b) (i) State the factors which determine the resistance of a wire of a given material. (2)

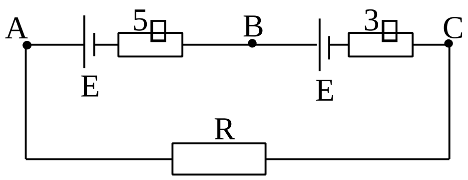
(ii) Explain why the resistance of a metal increases when the temperature of the metal is increased. (2)

(iii) Derive an expression for the equivalent resistance of three resistances, R_1, R_2 and R_3 connected in series. (3)

(c) You are provided with about 1 m of a bare constantan wire, an ammeter, a voltmeter, crocodile clips and some connecting wires.

Describe an experiment you would perform, using all but only the items provided, to determine the internal resistance of a cell. Give a diagram of your setup. (5)

(d) In the circuit shown below, each source has en emf of 2V and negligible internal resistance.



When a voltmeter is connected between A and B, it reads 0V. Find

(i) the value of the resistance R. (4)

(ii) the reading of the voltmeter when connected between B and C. (2)

2(a) Explain why the terminal p.d falls as the current drawn from a source increases. (3)

(b) A d.c source of emf 12 V and negligible internal resistance is connected in series with two resistors of 400 □ and R ohms, respectively. When a voltmeter is connected across the 400 □ resistor, it reads 4 V while it reads 6 V when connected across the resistor of R ohms. Find the:

(i) resistance of the voltmeter (6)

(ii) value of R (1)

(c) Describe how you would use a slide wire potentiometer to measure the internal resistance of a dry cell. (5)

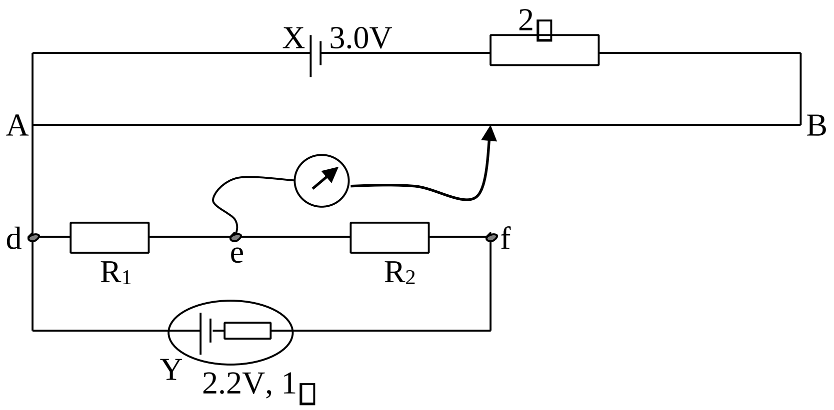
(d) In the circuit diagram shown below, AB is a slide wire of length 1.0 m and resistance 10 Ω. X is a driver cell of emf 3.0 V and negligible internal resistance. Y is a cell of emf 2.2 V and internal resistance 1.0Ω

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. (3)

(ii) resistances of R_1 and R_2. (2)



3 (a) Define

(i) capacitance (1)

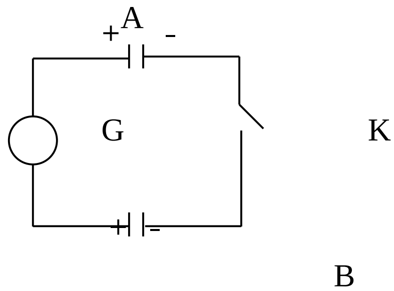
(ii) dielectric strength (1)

(b) Explain the action of a dielectric in a capacitor. (4)

(c) Describe an experiment to show that capacitance is affected by the thickness of the dielectric. (4)

(d) Derive an expression for the energy stored in a capacitor of capacitance C charge to a p.d V. (5)

(e) In the circuit shown below switch K is open, capacitors A and B have respective capacitances of 10μF and 15 μF and are charged to p.ds of 25 V and 20 V respectively.



A ballistic galvanometer G, with sensitivity of 2 divisions per □C joins the positive plates of the capacitors. If K is now closed, what will be the throw on G? (5)

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

(ii) Define the terms ***electric field intensity*** and ***electric potential at a point***. (2)

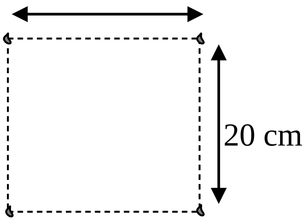
(b) (i) Sketch graphs of the variation of electric potential and electric field intensity with distance from the centre of a charged conducting sphere. (2)

(ii) Describe how a conducting body may be positively charged but remains at zero potential. (3)

(iii) Explain how the presence of a neutral conductor near a charged conducting sphere may reduce the potential of the sphere. (3)

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

20cm
-1□C P



+ □8□C **+1□C**

Calculate the:

(i) electric potential at P (4)

(ii) electric field intensity at P (5)

5(a) Define the terms

(i) Dielectric constant (1)

(ii) Equipotential (1)

(b) (i) State the characteristics of an equipotential. (2)

(ii) Explain the occurrence of corona discharge (3)

(c) Describe, with the aid of a diagram, how a high voltage can be generated using a Van de Graaff generator. (6)

(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 (4)

(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)

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

Find the condition for the maximum power dissipated in the variable resistance. (3)

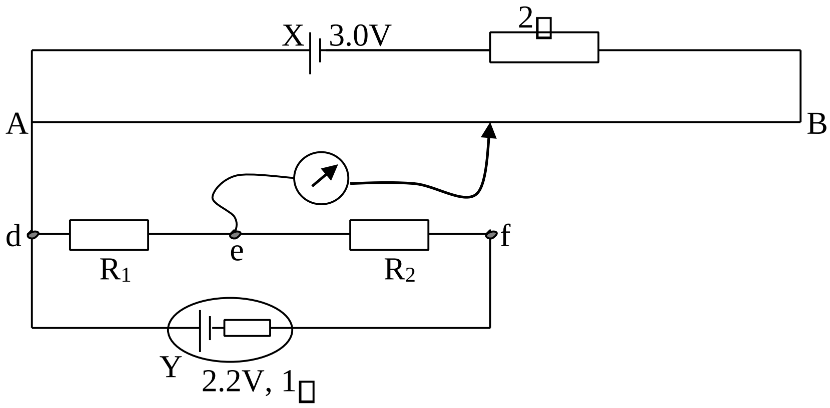
(b) A d.c source of emf 22 V and negligible internal resistance is connected in series with two resistors of 500 and R ohms, respectively. When a voltmeter is connected across the 500 Ω resistor, it reads 10 V while it reads 8 V when connected across the resistor of R ohms. Find the:

(i) resistance of the voltmeter (6)

(ii) value of R (1)

(c) Describe how you would use a slide wire potentiometer to measure the internal resistance of a dry cell. (5)

(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



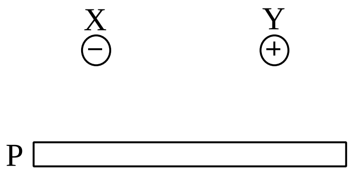
When the centre-zero galvanometer is connected in turns to points **e** and **f**, the balance lengths obtained are 45.0 cm and 80.0 cm respectively. Calculate the:

(i) current flowing through R_1. (3)

(ii) resistances of R_1 and R_2. (2)

7 (a) (i) Explain why a neutral conductor may be attracted to a charged body. (3)

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

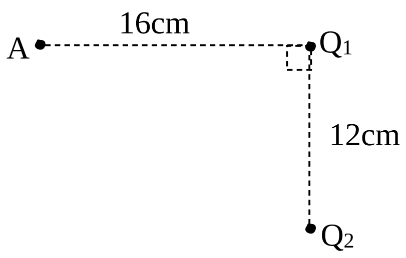


Sketch the electric field pattern in the region of the three bodies and indicate the neutral point(s). (3)

(b) Describe an experiment to investigate the charge distribution over the surface of a charged conductor. (5)

(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 □. (5)

(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. (4)

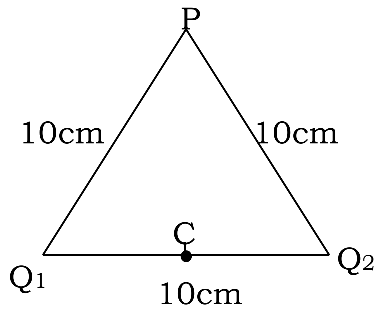
8(a) (i) Explain why a charged body attracts a neutral conductor. (3)

(ii) Explain the occurrence of corona discharge. (3)

(b) Describe an experiment to investigate the charge distribution over a conductor, showing how the conclusion is arrived at. (4)

(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. (5)

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



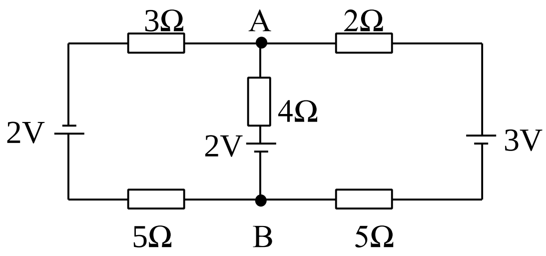
Find the work done in moving a charge of **–4 □C** from point P to point C midway between Q_1 and Q_2 and interpret the answer you have obtained. (5)

9 (a) (i) What is meant by ***potential difference***? (1)

(ii) Define a ***volt***. (1)

(b) Explain why the terminal p.d across a source decreases as a bigger current is drawn from the source. (3)

(c)



In the circuit shown above, find

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

(ii) the p.d between points A and B. (2)

(d) Describe an experiment to measure the internal resistance of a cell. (5)

(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? (4)

10(a) (i) What is meant by the dielectric constant? (1)

(ii) Derive an expression for the energy stored in a capacitor, of capacitance C, charged to a voltage V. (5)

(b) Explain the action of a dielectric. (4)

(c) Describe how the unknown capacitance of a capacitor can be determined using a ballistic galvanometer. (4)

(d) A capacitor of capacitance 5 □F 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 8□F. Calculate:

(i) the final p.d., V across the combination. (2)

(ii) the energy stored before and after connecting the two capacitors. (3)

(iii) Account for the difference in the quantities of energy calculated. (1)

11(a) (i) State Ohm’s law (1)

(ii) Describe an experiment to verify Ohm's law. (5) (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. (4)

(ii) the reading of the voltmeter when connected across the 300 Ω resistor. (3)

(c) Define

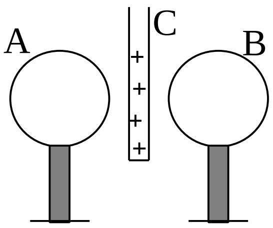
(i) ***electrical resistivity*** (1)

(ii) ***temperature coefficient of resistance*** (1)

(d) An electric element consists of 4.64 m of nichrome wire of diameter 0.5 mm, the resistivity of nichrome at 15°C being 1.12×10^{-6} Ωm. When connected to a 240V supply, the fire dissipates 2.0 kW and the temperature of the element is 1015°C. Determine the mean temperature coefficient of resistance of nichrome between 15°C and 1015°C. (5)

12(a) Explain how objects get charged by rubbing. (3)

(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.

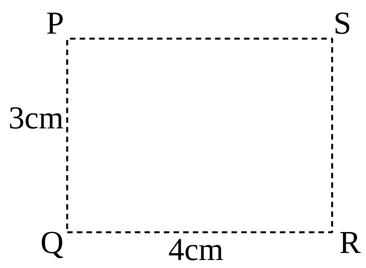
(i) Draw the spheres at the end of the operation and show the charge distribution over them. (2)

(ii) On the same diagram sketch the electric field pattern in the region of the spheres. (2)

(iii) Explain the change in p.d between the spheres as the spheres are moved further apart. (2)

(c) Describe an experiment to show that excess charge resides outside a hollow conductor. (5)

(d) Charges of **-3□C**, **+4□C** and **+3□C** 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. (6)

13(a) Define

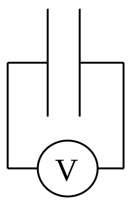
(i) ***capacitance*** (1)

(ii) ***dielectric strength*** (1)

(b) Describe an experiment to show the relationship between capacitor charge and potential difference. (5)

(c) Derive an expression for the equivalent capacitance of three capacitors connected in series. (3)

(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. (2)

(ii) the separation of the plates is increased. (2)

(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 8□C 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 36□C. Given that $C_1 < C_2$, find;

(i) the capacitances of the capacitors (4)

(ii) the p.d, V, of the supply (2)