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Contents

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Chapter 3: DC Circuits

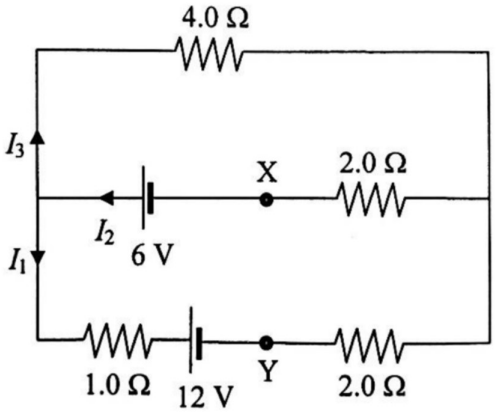
Questions

1. **[PSPM 11/12]**

   (a) State Ohm's Law

   (b) A potential difference of $15V$ is applied across a uniform wire of length $2.8m$ and radius $0.3cm$. If $0.6A$ current flows in the wire, calculate the resistance and the resistivity of the wire.

   (c) Two batteries and four resistors are connected in a circuit where currents I_1,I_2 and I_3 flow as shown in the figure below.



   i. Calculate currents I_1,I_2 and I_3.

   ii. What does it imply if the calculated current is negative?

   iii. Calculate the potential difference between points X and Y.

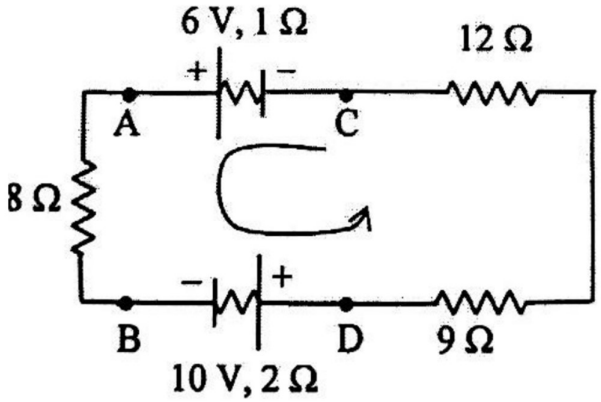
   iv. Calculate the total power dissipated in the circuit.

2. **[PSPM 12/13]**

   (a) Define the emf of a battery

   (b) A battery has an emf of $12V$ nad internal resistance r is connected to a resistor $R = 4\Omega$. The voltage across the battery terminal is measured to be $8V$. Calculate the internal resistance.

   (c) The figure below shows a circuit consisting of batteries with internal resistances $6V, 1\Omega$ and $10V, 2\Omega$ and connected to resistors 8Ω, 9Ω and 12Ω.



   By using the anticlockwise loop, calculate

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i. the current that flows through the 8Ω resistor

ii. potential difference between point A and C, V_{AC}

(d) The heating element is made of $1m$ long wire with crossectional area of $3.1\times10^{-6}m^2$. The wire has a resistivity of $\rho_o = 6.8\times10^{-5}\Omega m$ at temperature $T_o = 320^oC$ and a temperate coefficinet of resistivity $\alpha = 2.0\times19^{-3}K^{-1}$

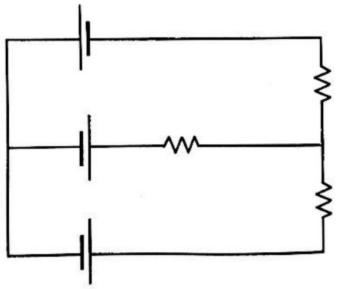
i. Define temperate coefficinet of resistivity α

ii. Determine the resistance of the heating element at an operating temperature of 420^oC

iii. If the heating element is connected to $100V$ power supply, is the power dissipated at 320^oC and 420^oC are the same? Justify your answer

3. **[PSPM 13/14]**

(a) State the two laws to be used in determining the currents in the circuit as shown below.



(b) A toaster has a heating element made of nichrome wire and connected to a $220V$ source. The wire is initially at 20^oC with current $1.8A$. When the toacter reaches it final operating temperature, the current is $1.53A$. Calculate the

i. power delivered to the toaster at its operating temperature

ii. final temperature of the heting element if the temperature coefficient of resistivirt for nichromw wire is $4\times10^{-4o}C^{-1}$

(c) The emf of a battery with internal resistance is $12V$. When an unknown resistor R is connected to the battery, the current is $0.8A$. If another resistor R is added in series, the current is $0.6A$. Calculate the

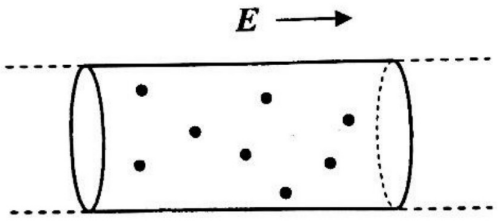
i. value of the resistor R.

ii. internal resistance of the battery.

iii. terminal voltage of the battery.

4. **[PSPM 14/15]**

(a) The figure below shows some of the free electrons inside a section of a cylindrical copper wire. The wire is connected to an emf source, and the direction of the electric field, E as indicated in the figure.



i. Sketch the diagram to show the motions of one free electron, the directions of drift velocity and the current.

ii. If the current in the wire is $50mA$, calculate the number of electrons passing a point in $10s$.

(b) A battery has an emf of 9 V. The terminal voltage is $8V$ when the battery is connected across a resistor of 5Ω . Calculate the

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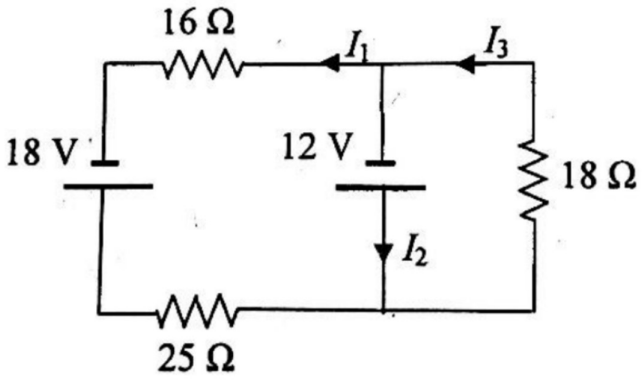
i. current through the resistor
ii. power dissipated by the resistor
iii. internal resistance of the battery.



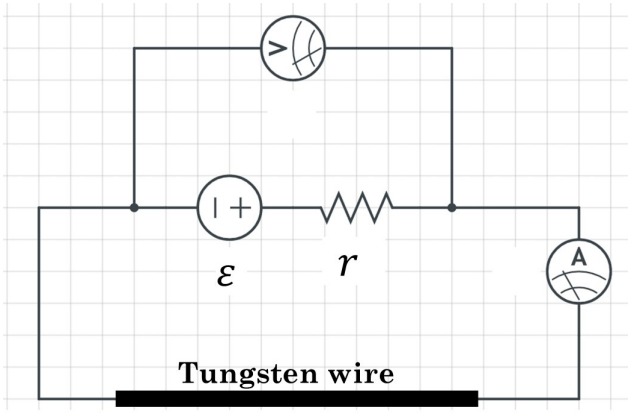
(c)

By referring to the figure above, calculate

i. I_1, I_2 and I_3
ii. the potential difference across the 18Ω resistor.

5. **[PSPM 15/16]**

(a) The figure below shows a tungsten wire connected to a battery with internal resistance r. At room temperature of 23^oC , the readings of voltmeter and ammeter are $8.74V$ and $437mA$ respectively.

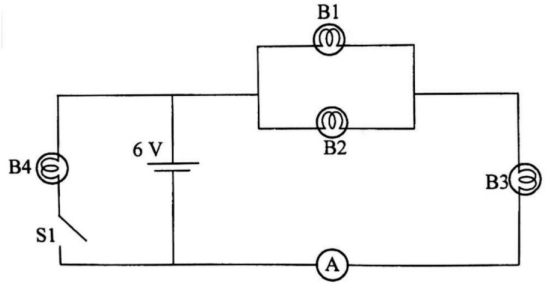


i.

After the tungsten wire is heated to 190^oC, the voltmeter reading is $8.85V$ and the ammeter reading is $253mA$. Calculate the

i. emf and internal resistance of the battery
ii. temperature coefficient of resistivity of tungsten wire

(b) The figure below shows four identical bulbs connected to a $6V$ battery and a switch.



When the switch is off, the ammeter reading is $0.5A$.

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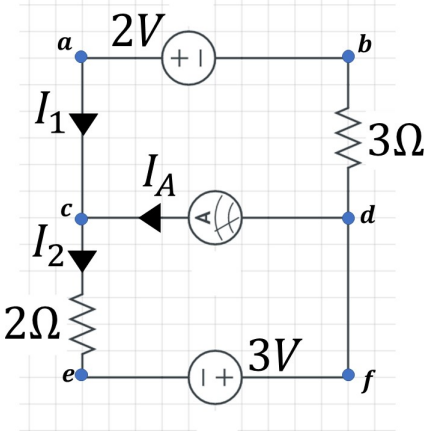
i. Calculate the resistance of a bulb.
ii. What happen to the reading of the ammeter when the switch is on? Explain your answer.

6. **[PSPM 16/17]**

(a) State Ohm's laws

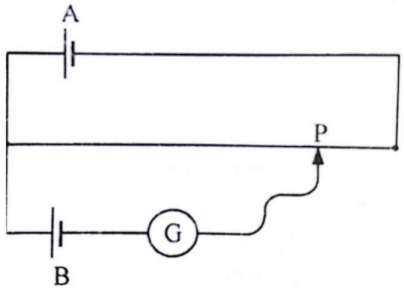
(b) i. You are given several $1k\Omega$ resistors. How do you connect the resistors to a circuit that requires a 500Ω resistance? Show your suggestion.

ii. shows a circuit consisting of two batteries, two resistors and an ammeter.



If the ammeter has internal resistance of 5.0Ω, what is the reading shown by the ammeter?

(c) shows a potentiometer circuit consist of a uniform wire XY of length $100cm$ and its resistance 5.0Ω.



The emf of cell A and B is $4.0V$ and $3.0V$ respectively. The internal resistance of both cells are negligible.

i. What is the length of XP when the galvanometer reading is zero?
ii. If a 1.0Ω resistor is connected in series with cell A, what is the new balance length XP?

7. **[PSPM 17/18]**

(a) Explain the effect of temperature on the electric resistance of metals.

(b) The resistivity of a cooper wire is $1.72 \times 10^{-8}\Omega m$. An electric current of $2.07A$ flows in the wire. If the wire has a cross sectional area of $8.0 \times 10^{-7}m^2$ and length of $50m$, calculate

i. resistance of the wire
ii. potential difference across the wire
iii. energy dissipated in 1 minute.
iv. Total energy dissipated,

(c) Determine I_1, I_2 and I_3 in the figure below.

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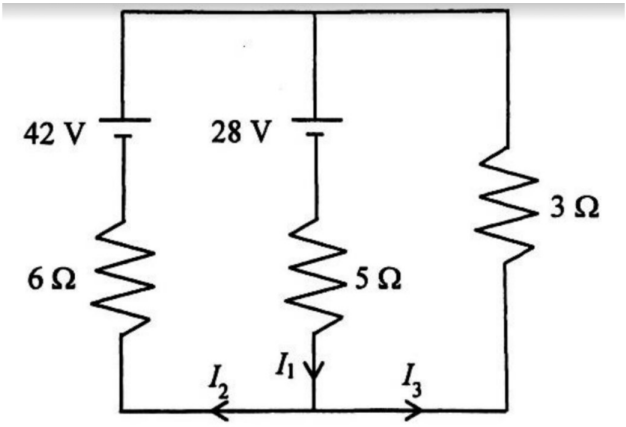


8. **[PSPM 18/19]**

(a) Calculate the number of electrons that flow in a wire if it carries a current of $2A$ for $5s$.

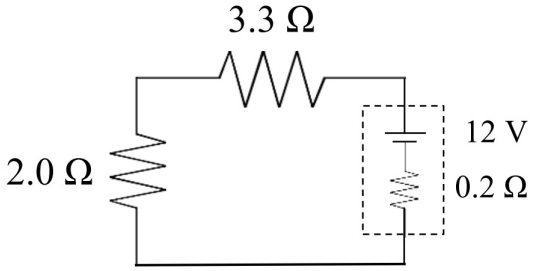
(b) A 2.5 kW heater is connected to a 220 V power supply.

i. Calculate the current and resistance in the heater.

ii. The coil of heater is made from a wire of cross-sectional area $2 \times 10^{-7} m^2$ and resistivity $1.1 \times 10^{-6} \Omega m$. Calculate the length of the wire.

iii. The voltage of the power supply is then changed to $110V$. Calculate the new power output of the heater.

(c) The figure below shows a circuit with a battery having an emf of $12V$ and internal resistance of 0.2Ω connected in series to two resistors, 3.3Ω and 2.0Ω.



Calculate

i. the current in the circuit.

ii. the terminal voltage across the battery.

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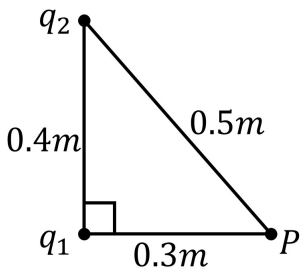
Chapter 1: Electrostatics

Questions

1. **[PSPM 11/12]**

   (a) State Coulomb's Law

   (b) Two point charges $q_1 = +3.00\mu C$ and $q_2 = -5.00\mu C$ are placed at the two corners of a triangle of sides $0.30m$, $0.40m$ and $0.50m$ as shown in the figure below. P is the third corner of the triangle.



   Calculate

   i. the magnitude of the electric field at P.

   ii. the electric potential at P.

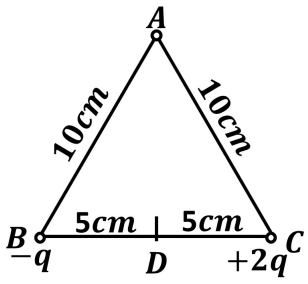
   iii. the work needed to bring a test charge from infinity to P.

2. **[PSPM 12/13]**

   (a) i. Define the electric potential V at point P in an electric field.

   ii. An isolated charge $Q = 5(10^{-6})C$ is placed in a region and it creates an electric field around it. Calculate the work done to move a point charge $q = 2(10^{-7})C$ from point S to point P which is located at $60cm$ and $30cm$ respectively from charge Q.

   (b) The figure below shows two point charges $-q$ and $+2q$ placed at points B and C respectively.



   If $q = 1(10^{-6})C$, calculate

   i. the electric field at point D

   ii. the potential energy of all charges when the point charge $2(10^{-6})C$ is placed at A.

3. **[PSPM 13/14]**

   (a) The figure below shows a charge Q at the vertex of an equilateral triangle with sides $1mm$.

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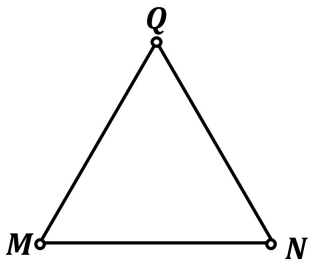


If the $138J$ of work is done in bringing a $-4.8\mu C$ point charge from infinity to position M.

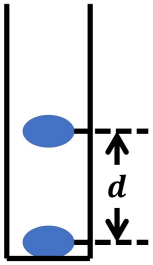
i. Determine the magnitude and type of charge Q

ii. calculate the electric field at position N.

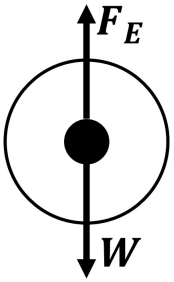
4. **[PSPM 14/15]**

(a) What is meant by electric field strength at a point in an electric field?

(b) The figure below shows a charged ball floating vertically above an other charged ball at an equilibrium distance d apart in a test tube.



i. Sketch the forces acting on the floating ball.



ii. What is the type of charge on the balls.

iii. If the charge on each ball is tripled, determine the new equilibrium distance between the balls in terms of d.

5. **[PSPM 15/16]**

(a) Define electric field and electric potential

(b) The figure shows two charges $+50\mu C$ and $-20\mu C$ separated by $0.8m$.

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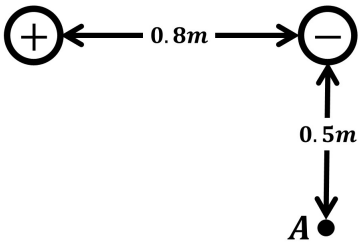
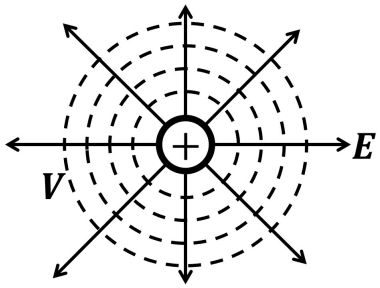


Determine the

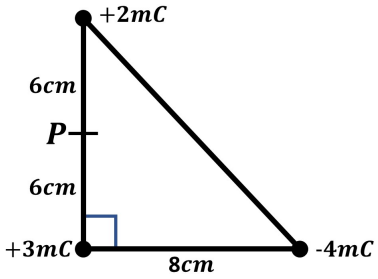
i. electric field at point A due to the negative charge.
ii. electric potential at point A
iii. external work required to bring $+2\mu C$ charge from infinity to point A.

6. **[PSPM 16/17]**

(a) The strength of a uniform electric field is $200 V m^{-1}$. What is meant by the statement?
(b) Sketch a diagram to show the equipotential lines and electric field lines of an isolated positive charge.



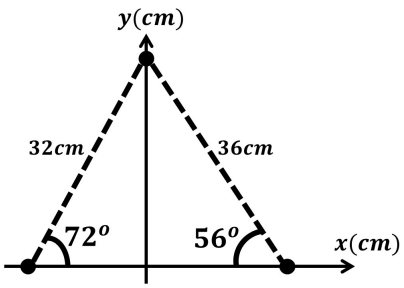
(c) The figure below shows three point charges placed at each vertices of a right angle triangle.



Calculate the electric potential at point P and the electric potential energy of the system.

7. **[PSPM 17/18]**

(a) Define Coulomb's Law and capacitance
(b) The figure below shows charges $Q_1 = +5\mu C$, $Q_2 = -4\mu C$ and $Q_3 = +4\mu C$ in $x - y$ plane.



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Determine the magnitude and direction of the net electric force on Q_3.

8. [**PSPM 18/19**]

(a) The figure below shows $Q_1 = +8\mu C$ and $Q_2 = -6\mu C$ placed $4m$ apart.

i. Calculate the electric potential at points A and B.

ii. Calculate electric potential difference between points A and B.

iii. Determine the electric field at point A.

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Chapter 5: Electromagnetic Induction

Questions

1. **[PSPM 11/12]**

   (a) i. Define magnetic flux
   ii. State Faraday's Law of magnetic induction

   (b) The plane of a coil of radius $0.2m$ is parallel to the yz-plane in a uniform magnetic field. The magnetic field is $0.4T$ and in the positive $x-$direction.
   i. Calculate the magnetic flux through the coil.
   ii. The coil is then rotated clockwise about the y-axis, such that the normal of the coil is now 30^o with respect to the x-axis. Calculate the average induced emf in the coil if the time taken for the rotation is $0.5s$.

   (c) A current of $5A$ is flows in a 400 turn solenoid that has a length of $30.0cm$ and cross sectional area of $2.00 \times 10^{-4}m^2$. Calculate
   i. the inductance of the solenoid.
   ii. the energy stored in the solenoid.
   iii. the induced emf in the solenoid
   iv. the induced emf in the solenoid if the current in the solenoid decreases uniformly to zero in $0.2s$.

2. **[PSPM 12/13]**

   (a) A circular coil of N turns and radius r is rotated at constant frequency f in a uniform magnetic field B. The magnetic flux linkage of the coil is given by

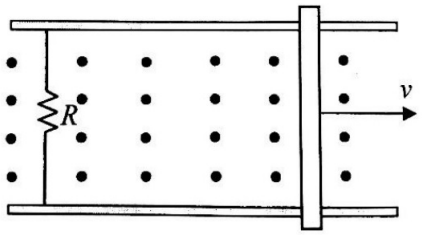
   $$\phi = N\pi r^2 B cos\,(2\pi ft)$$

   .
   i. Deduce the expression for emf induced in the coil.
   ii. If $N = 100$ turns, $r = 5$ cm, $B = 1.0T$ and $f = 50Hz$, calculate the maximum emf generated.
   iii. A rotating coil generates a maximum emf of $500V$. Calculate the number of turns if the radius is $5cm$ and rotates at the same frequency.

   (b) A solenoid of length $l = 10cm$, radius $r = 2cm$ has $1000turns$.
   i. The current of the solenoid is lowered from $5A$ to $0A$ within $0.3s$. Calculate the magnitude of emf induced in the solenoid.
   ii. A second coil with $50turns$ is wound coaxially with the solenoid. Calculate the mutual inductance between the two.
   iii. What is the induced voltage ratio of the coil to the solenoid?

3. **[PSPM 13/14]**

   (a) The figure below shows a bar moving on rails to the right with a velocity v in a uniform magnetic field directed out of the page. A resistor R connects the rails.



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i. What is the direction of induced current in resistor R? Explain your answer.
ii. State TWO ways to increase the induced current with R fixed.

(b) A rectangular coil of 60 turns, dimensions $0.1m \times 0.1m$ and total resistance 10Ω, rotates with angular speed $30rads^{-1}$ about the y-axis in a $1.5T$ magnetic field directed along the x-axis. Calculate the

i. maximum induced emf in the coil.
ii. maximum rate of change of magnetic flux through the coil.

(c) Two coaxial solenoids, P and Q have 400 and 700 turns respectively. A current of $3.5A$ in coil P produces an average flux of $300\mu Wb$ through each turn of P and average flux of $90\mu Wb$ through each turn of Q. Calculate the

i. inductance of solenoid P
ii. mutual inductance.

4. **[PSPM 14/15]**

(a) i. Define magnetic flux.
ii. A $0.2T$ magnetic field is directed parallel to the plane of a circular loop of radius $0.2m$. Calculate the magnetic flux through the loop.

(b) i. A coil of 100 turns and area $0.5cm^2$ is placed in a changing magnetic field. The rate of change of magnetic field is $1.08Ts^{-1}$. Calculate the induced emf in the coil.
ii. A coil of N turns with an area $6.8 \times 10^{-2}m^2$ is rotating at frequency $90Hz$ in a uniform magnetic field $0.28T$. If the maximum induced emf in the coil is $128.5V$, calculate the value of N.

(c) A solenoid of radius $5cm$ has 200 turns and length of $15cm$. Calculate the

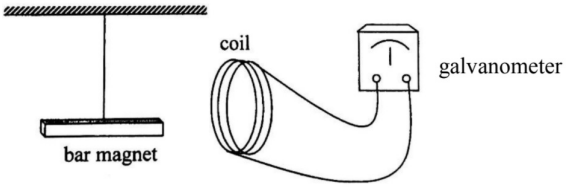
i. inductance.
ii. rate at which current must change for it to produce an induced emf of $50mV$.

(d) Two coaxial coils are wound around the same cylindrical core. The primary coil has 350 turns and the secondary has 200 turns. When the current in the primary coil is $6.5A$, the average flux through each turn of the secondary coil is $0.018Wb$. Calculate the

i. mutual inductance of the pair of coils.
ii. average flux through each turn of the primary coil when the current in the secondary coil is $1.5A$.

5. **[PSPM 15/16]**

(a) A bar magnet is hanging by a string as shown in the figure below.



When the magnet is swung towards the coil, the galvanometer needle deflects to the right.

i. Why the galvanometer needle deflects?
ii. What happen to the galvanometer when the magnet moves away from the coil? State the law to explain this phenomenon.
iii. If the magnet is static but the coil is brought towards the magnet, what will happen to the galvanometer?

(b) A rectangular coil of 250 turns and size $20cm \times 30cm$ rotates at a constant angular velocity of $500rpm$ in a uniform magnetic field of $40mT$.

i. Calculate the maximum magnetic flux through the coil.
ii. Calculate voltage produced by the coil when coil plane makes an angle 30^o with the magnetic field.
iii. What is the maximum voltage produced by the coil?

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(c) The current flowing through a solenoid changes from $1.75A$ to $3.00A$ within $1.25ms$. The back emf induced across the solenoid due this change is $6V$.

i. Calculate the self inductance of solenoid.

ii. If the length of the solenoid is $25cm$ and the cross-sectional area is $40cm^2$, calculate the number of turns of the solenoid.

6. **[PSPM 16/17]**

(a) State

i. Faraday's law of electromagnetic induction.

ii. Lenz's law

(b) A coil of 60 turns and cross-sectional area $4.65 \times 10^{-4}m^2$ is placed in a uniform magnetic field of $0.80T$. The plane of the coil is perpendicular to the field.

i. Calculate the total magnetic flux through the coil.

ii. Calculate the average induced emf generated in the coil if the magnetic field is reduced to zero in $0.50s$.

iii. Sketch a diagram to show the direction of the induced current in the coil with respect to the direction of magnetic field based on the condition in 4(b)(ii). Explain.

(c) A $6.0mH$ and a switch are connected in series to a $15V$ battery. The total resistance of the circuit is 8.0Ω. When the switch is closed, calculate the

i. initial rate of current change

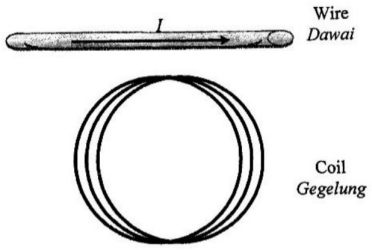
ii. final value of the current

iii. final energy stored in the inductor.

7. **[PSPM 17/18]**

(a) State Faraday's Law.

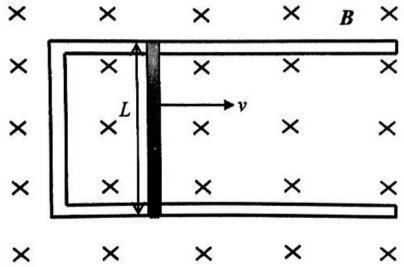
(b) A long straight wire carrying current, I is placed near a coil as in the figure below.



i. If I is decreasing in magnitude, determine the direction of the induced current and the direction of the induced magnetic field in the coil.

ii. If I is constant in magnitude, give two ways to induced current in the coil.

(c) The figure below shows a conductor of length $L = 0.065m$ moves perpendicularly in a uniform magnetic field of $1.20T$. The emf induced in the conductor is $0.32V$.



i. Calculate the speed of the conductor.

ii. If the total circuit resistance is 0.8Ω, determine the magnitude and direction of the induced current.

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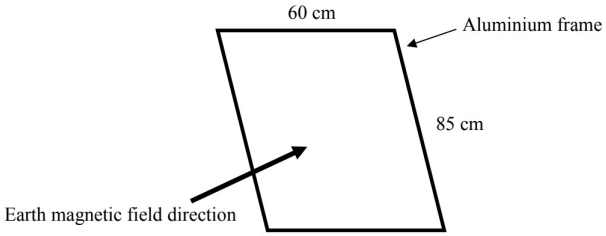
(d) A solenoid of inductance $7.3mH$ has a 450 turns and length $24cm$. Determine the

i. cross sectional area of the solenoid

ii. induced emf in the solenoid if its current drops from $3.2A$ to zero in $55ms$.

8. **[PSPM 18/19]**

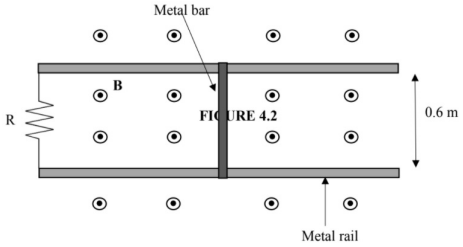
(a) The figure below shows the earth's magnetic field of $1.8 \times 10^{-4}T$ normal to an aluminium frame of dimensions $60cm \times 85cm$.



i. Calculate the magnetic flux through the frame.

ii. The frame is flipped so that it is parallel to the earth magnetic field in $0.2s$. Calculate the induced emf.

(b) The figure below shows a $0.6m$ long metal bar being pulled to the right at a steady speed of $5.7ms^{-1}$ perpendicular to a uniform $0.7T$ magnetic field. The metal rails are connected to a 5Ω resistor.



i. Calculate the magnitude of the emf induced in the circuit.

ii. Calculate the current through the resistor and its direction in the metal bar.

(c) A solenoid of length $8 \times 10^{-2}m$ and cross sectional area $5 \times 10^{-5}m^{-2}$ contains 6500 turns per meter length. Calculate the self inductance of the solenoid.

9. **[PSPM 19/20]**

10. **[PSPM 19/20]**

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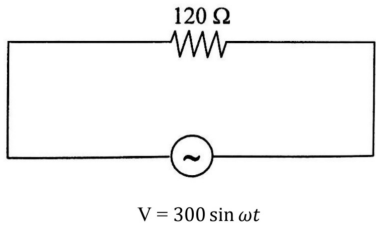
Chapter 6: AC circuit

Questions

1. **[PSPM 11/12]**

   (a) An AC source has an output voltage of $V = 300\,sin\,\omega t$. The source is connected to a 120ω resistor as in the figure below.



   i. Calculate the rms voltage.
   ii. Calculate the rms current in the resistor.
   iii. Calculate the average power delivered in the circuit.
   iv. What is the rms voltage if the frequency is doubled?

   (b) An AC source that has a peak voltage of $120V$ and a frequency of $50Hz$ is connected in series to a 900Ω resistor, a $2.4H$ inductor and a $10.0\mu F$ capacitor. Calculate

   i. the impedance of the circuit
   ii. the phase angle of the circuit
   iii. the power factor of the circuit.

2. **[PSPM 12/13]**

   (a) In an alternating circuit, the supply voltage is given by $V = 240sin(5000t + \frac{\pi}{2}t)$ where V in volt and the current is given by $I = 0.480sin(5000t)$ where I in ampere and t in second.

   i. What is meant by root mean squared (rms) value of the current?
   ii. Calculate the impedance of the circuit.
   iii. Sketch the phasor diagram for V and I and state the electrical component either RCL, RC or RL. Give your reason.
   iv. Calculate the instantaneous and maximum power dissipated in the circuit.

   (b) A resistor of 6Ω, a capacitor of $3000\mu F$ and inductor of $5mH$ are connected in series. If an AC source of $50Hz$ and peak voltage of $240V$ is connected to this circuit combination, calculate

   i. the total impedance of the circuit.
   ii. the resonance frequency of the circuit and explain the energy dissipated during resonance.

3. **[PSPM 13/14]**

   (a) A voltmeter shows a reading of $220V$ for a $50Hz$ AC voltage.

   i. Calculate the maximum value of the AC voltage.
   ii. Write the equation for the AC voltage.

   (b) A $0.9k\Omega$ resistor, $0.25\mu C$ capacitor and $2.5H$ inductor are connected in series across a $240Hz$ AC source with $140V$ peak voltage.

   i. Calculate the impedance.
   ii. Calculate the maximum current.
   iii. Calculate the phase angle between the current and voltage.

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iv. Which quantity lags : current or voltage? Explain your answer.
v. How to achieve resonance in the circuit?

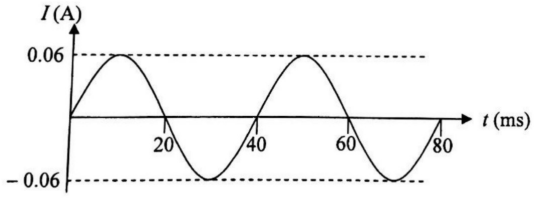
4. **[PSPM 14/15]**

(a) An RL series circuit with a $0.056H$ inductor and 250Ω resistor is connected with a source of peak voltage $240V$ at the frequency $200Hz$. Calculate the
i. inductive reactance of the circuit.
ii. impedance of the circuit.
iii. power factor for this circuit.
iv. rms voltage of the source.
v. average power delivered by the source.

(b) An RLC circuit consist of a 40Ω resistor, a $22mH$ inductor and a $400nF$ capacitor connected in series to the AC source which has a peak voltage of 100 mV and a frequency of $1.6kHz$.
i. Calculate the capacitive reactance.
ii. Calculate the rms current.
iii. Determine the phase angle.
iv. Sketch the phasor diagram to represent the voltages across the components and the source.

5. **[PSPM 15/16]**

(a) The figure below shows a graph of alternating current through a 220Ω resistor.



i. Calculate the rms current through the resistor.
ii. Calculate the peak voltage across the resistor.
iii. State the equation of voltage across the resistor.
iv. Calculate the average power dissipated by the resistor.

(b) A sinusoidal voltage $V(t) = 20sin(50\pi t)$ is applied to a series RLC circuit with R = 670Ω , $L = 250mH$ and $C = 47\mu F$.
i. Calculate the impedance of the circuit.
ii. Calculate the phase angle of the circuit.
iii. The frequency of AC source is adjusted until it draws maximum current. Calculate the frequency of AC source at this instant.
iv. When the frequency of AC source is adjusted, does it change the power dissipated by the circuit?

6. **[PSPM 16/17]**

(a) Define alternating current.

(b) A $3.0k\Omega$ resistor and in inductor are connected in series with a $12V$ AC supply. The inductor's reactance is $4.7k\Omega$.
i. Calculate the impedance of the circuit.
ii. Find the rms current in the circuit.
iii. Sketch a phasor diagram to show the voltages cross the resistor V_R and the inductor V_L , and the supply voltage V.

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(c) An electric motor is connected to a $230V, 50Hz$ AC supply. The motor has a resistance of 15Ω. and inductive reactance of 27Ω. Calculate the

i. power factor of the system
ii. average power
iii. the value of capacitor to be added in series with the motor so that the power factor is 1.

7. **[PSPM 17/18]**

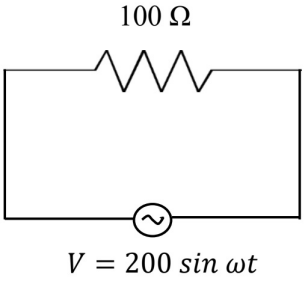
(a) i. Give two characteristics of a series RLC alternating current circuit at resonance.
ii. If a frequency at an AC circuit is increasing, what happens to the resistance, capacitive reactance and inductive reactance?

(b) An RLC circuit with resistance 160Ω, capacitance $15\mu F$, inductance $230mH$ frequency $60Hz$ and peak voltage $36V$. Calculate the

i. impedance
ii. phase current between the current and the voltage
iii. rms current
iv. average power dissipated in the resistor.

8. **[PSPM 18/19]**

(a) The figure below shows an AC source with a voltage of $V = 200\,sin\,\omega t$ connected to a 100Ω resistor.



i. rms voltage.
ii. rms current in the resistor.
iii. average power delivered to the circuit.

(b) A series RLC circuit consisting of 35 mH inductor, $45\mu F$ capacitor and 85Ω resistor is connected to an AC generator of $150V$, $60Hz$. Calculate the

i. Capacitive reactance.
ii. inductive reactance.
iii. impedance.
iv. phase angle

Chapter 7: Geometrical Optics

Questions

1. **[PSPM 11/12]**

(a) An object $4cm$ hight is placed $15cm$ from a convex mirror of focal length $5cm$. Determine the position of the image from the mirror, the magnification of the image and the height of the image.

2. **[PSPM 12/13]**

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(a) The focal length of a converging biconvex glass (with $n = 1.5$) is $20cm$.

i. Calculate the radius of curvature of the lens.

ii. If the lens if placed in a liquid of refractive index of 1.63, calculate the new focal length and state the lens type.

3. **[PSPM 13/14]**

(a) A lens is made of glass with refractive index 1.6 and radii of curvatures $r_1 = 6cm$ and $r_2 = 4cm$. An object is located $30cm$ from the lens. Calculate the focal length of the lens and determine two characteristics of the image by diagram sketch.

4. **[PSPM 14/15]**

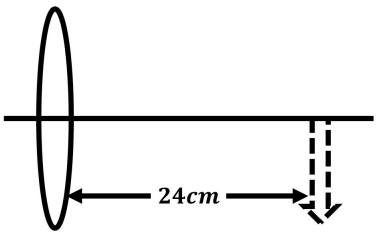
(a) Write the lensmakers' equation and explain the sign convention used for the radii of curvatures.

(b) The figure below shows a converging lens made of a material of refractive index 2.26. One surface of the lens is a plane and the other has a radius of curvature $14.5cm$.

Determine the focal length of the lens.

5. **[PSPM 15/16]**

(a) An image of $15cm$ height is formed $24cm$ behind the convex lens as shown in the figure below.



Calculate the

i. object distance

ii. focal length of the lens

(b) An object placed $10cm$ in front of a curved mirror produced an image $5cm$ behind the mirror. Calculate the focal length of the mirror and state the type of mirror.

6. **[PSPM 16/17]**

(a) An object is $20cm$ from a convex lens of focal length $12cm$. Calculate the image distance and the magnification of the image formed by the lens.

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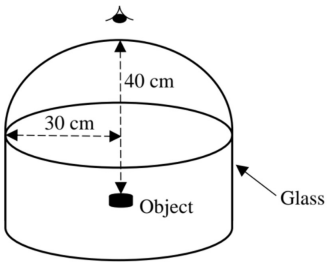
7. **[PSPM 17/18]**

   (a) State Huygen's Principle Ans: Every point on a wavefront may be considered a source of secondary spherical wavelets which spreads out in the forward direction at the speed of light

   (b) An object is placed in front of a concave mirror with $25cm$ radius of curvature. A real image twice the size of the object is formed. Sketch a ray diagram to illustrate the formation of the image.

8. **[PSPM 18/19]**

   (a) The figure below shows an object embedded in a solid glass with a hemispherical end of radius $30cm$ and refractive index 1.50. The object is $40cm$ inside the glass.



   Calculate the image distance. Refractive index of air is 1.

   (b) A $2cm$ height object is placed $7cm$ from a concave mirror whose radius of curvature is $12cm$. Determine the image distance, image height and give two characteristics of the image.

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Chapter 8: Physical Optics

Questions

1. **[PSPM 11/12]**
   Light 540nm wavelength is incident on a slit 0.240mm wide. A screen is placed 2.00m from the slit.
   (a) Determine of the first dark fringe.
   (b) Calculate the width of the central bright fringe.
   (c) What is the effect on the intensity of the central bright fringe if a narrower slit is used?

2. **[PSPM 12/13]**
   In a Young's double-slit experiment , the light source simultaneously emits blue light of wavelength 400nm and yellow light of wavelength 600nm. The slits are 0.08mm apart and the interference pattern is observed on a screen at a distance of 60.0cm from the slits. Calculate
   (a) the distances of the first blue and the first yellow fringes from the central fringe (that is, the zeroth fringe)
   (b) the shortest distance from the central fringe where the yellow and blue fringes overlap.
   Ans: Red and blue fringes overlap at the same distance from the central fringe

3. **[PSPM 13/14]**
   (a) -N/A-

4. **[PSPM 14/15]**
   A double-slit pattern is viewed on a screen 1 m from the slits. If the third order minimum are 20cm apart, determine the
   (a) ratio of wavelength to separation between the slits.
   (b) distance between the first order minimum and third order maximum on the screen.

5. **[PSPM 15/16]**
   (a) White light is incident on a soap film of refractive index 1.33 in air. The reflected light looks bluish because the red light of wavelength 670nm is absent in the reflection.
      i. Does the light change phase when it reflects at air-film interface? Explain your answer.
      ii. Does the light change phase when it travels in film and reflects at film-air interface?
      iii. What happen to the wavelength and frequency of light when it travels from air to the film?
      iv. Determine the minimum thickness of the soap film.

6. **[PSPM 16/17]**
   A beam consist of two monochromatic lights 400nm and 600nm, is incident normally on a diffraction grating which has 540$lines mm^{-1}$. Calculate the
   (a) angular separation between the first-order diffraction of the lights.
   (b) highest order of diffraction that can be observed with the 600 nm light.

7. **[PSPM 17/18]**
   (a) The figure below shows a flint glass lens of refractive index 1.61 is coated with a thin layer film of magnesium fluoride of refractive index 1.38 . A ray of light of wavelength 565nm is incident at right angles to the film.

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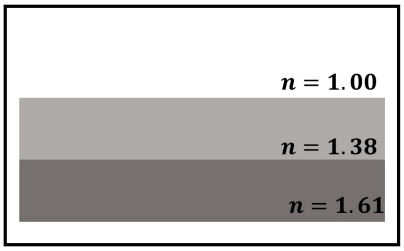


i. Sketch the light rays that interfere after being reflected from both surfaces of the film. Label the reflected rays that undergo phase change.

ii. What minimum thickness should the magnesium fluoride film have if the reflection of the $565nm$ light is to appear dark?

iii. If a lens is used to suppress the reflection of light at high frequencies, what should be done to the thickness of the film? Explain your answer.

8. [**PSPM 18/19**]

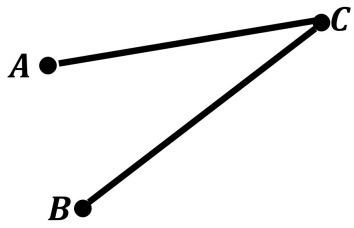
(a) Orange light of wavelength $600nm$ is incident normal to a diffraction grating having 3500 lines per cm.

i. Calculate the slit separation.

ii. Determine the maximum number of bright fringes that can be observed.

iii. How can the number of bright fringes be increased?

(b) The figure below shows shows two paths of coherent lights from points A and B that produced an interference pattern at point C.



Determine whether it is constructive or destructive interference if AC and BC are 2.2λ and 5.7λ respectively.

(c) Calculate the thickness of a soap film so that a $600nm$ light incident to the film would produce constructive interference. Index of refraction of soap film is 1.33.

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Chapter 11: Nuclear & Particle Physics

Questions

1. **[PSPM 11/12]**

   (a) i. Define nuclear binding energy.
   Ans: The energy needed to disintegrate the nucleon to free nucleons.
   ii. Given the mass of a $^{11}_{5}B$ nucleus is $11.008757u$, calculate the binding energy per nucleon.

   (b) Show that the radioactive decay equation can be written as $N = N_o \left(\frac{1}{2}\right)^{\frac{t}{T_{0.5}}}$

   (c) A sample of $^{2}11_{8}3Bi$ contains 2.00×10^9 nuclei. Given the half life of $^{2}11_{8}3Bi$ is 2.14minutes, calculate
   i. the initial activity in decays per second.
   ii. the number of the nuclei remaining after $42.8s$

2. **[PSPM 12/13]**

   (a) State the properties of particles emitted during radioactive decay.

   (b) State the risk arises from radioactive particles.

   (c) The activity of a sample of Radon-222 is $200Bq$. The half-life of Radon is $3.8\,days$.
   i. Calculate the decay constant of radon-222.
   ii. Calculate the number of Radon-222 atoms in the sample.
   iii. How long does it take for the activity to decrease to 60 Bq?

3. **[PSPM 13/14]**
   A prepared sample of radioactive isotope has an activity of $10.0mCi$. After 4 hours, the activity is $8.0mCi$. Calculate the

   (a) half-life of the isotope.

   (b) number of the isotope in the prepared sample.

   (c) sample activity 30 hours after it is prepared.
   (Given 1 Ci = 3.7 × 1010 decay per second)

4. **[PSPM 14/15]**
   Iodine-131 is among the radioactive isotopes leaked from the crippled Fukushima Daiichi Nuclear Power Plant after the 2011 Tõhoku earthquake and tsunami in Japan. The half-life of the Iodine-131 nucleus is 8.0197 days. If a sample initially contains 3.00×10^{16} iodine-131 nuclei, calculate the

   (a) decay constant.

   (b) initial activity.

   (c) activity after 20 days.

5. **[PSPM 15/16]**

   (a) Define binding energy.
   Ans: The energy required to separate completely all the nucleons in the nucleus

   (b) Calculate the energy needed to remove a neutron from $^{13}_{6}C$
   Given : mass of $^{12}_{6}C = 12.000000u$ and $^{12}_{6}C = 13.003355u$

   (c) The activity of a radioactive source decreases by 5% in 28 hours. Calculate the half-life of the source.

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6. **[PSPM 16/17]**

   (a) A foil of beryllium-9 ($^{9}_{4}Be$) is irradiated with alpha particles. The process produces carbon-12 and emits an intense radiation. Atomic masses of $^{4}_{2}He$, $^{9}_{4}Be$ and $^{1}2_{6}C$ are $4.00260u$, $9.01212u$ and $12.00000u$, respectively.

      i. Calculate the mass difference of the reaction in atomic mass unit.

      ii. Find the energy equivalent of the lost mass in MeV.

   (b) 8 days after its preparation, the activity of a sample of radioisotopes was 540 decays per second. The activity further reduced to 200 decays per second after 14 days from the date of preparation. Calculate the decay constant and the half-life of the radioisotope.

7. **[PSPM 17/18]**

   (a) Sketch the graph of binding energy per nucleon against nucleon number. Label the regions for possible nuclear fission and fusion on the graph.

   (b) A sample of radioactive nuclide ^{199}Pt has an initial activity of 7.56×10^{11} Bq.

      i. After $92.4 minutes$, the activity has decreased to 9.45×10^{10} Bq. Calculate the half life of the nuclide.

      ii. How many radioactive nuclei were initially present in the sample?

   (c) In a nuclear reaction, when a nuclide $^{7}_{3}Li$ is bombarded by a proton, two alpha particles $^{4}_{2}He$ are produced. The reaction is given by

$$^{1}_{1}H + ^{7}_{3}Li \rightarrow ^{4}_{2}He + ^{4}_{2}He$$

   Given the mass of $^{1}_{1}H$ is $1.007825u$, the mass of $^{7}_{3}Li$ is $7.016004u$ and the mass of $^{4}_{2}He$ is $4.002603u$. Calculate the energy released in MeV.

8. **[PSPM 18/19]**
   A $2g$ sample of radioactive iodine $_{5}3^{1}31I$ has a half life of 8 days.

   (a) Calculate the decay constant.

   (b) Calculate the initial number of atoms in the $2g$ sample.

   (c) Calculate the activity of the sample after 2 days.

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Chapter 9: Light Quantization

Questions

1. **[PSPM 11/12]**
   A cessium surface is illuminated with a light of wavelength 380 nm. The work function for cessium is 2.14 eV. Calculate
   (a) the energy of the photon in eV
   (b) the maximum kinetic energy of the photoelectrons
   (c) the threshold frequency for cessium
   (d) the stopping potential for the photoelectrons

2. **[PSPM 12/13]**
   (a) Explain the following terms - **Photon, Work function and Photoelectric current.**
   (b) The minimum frequency of electromagnetic radiation which will cause photoelectric emissions from a metal is $4.7 \times 10^{14} Hz$.
      i. Calculate the work function of the metal in eV.
      ii. If the metal surface is hit by electromagnetic radiation of frequency is $7.1 \times 10^{14} Hz$, calculate the maximum kinetic energy of the photoelectron.

3. **[PSPM 13/14]**
   (a) State TWO characteristics of light in the classical theory that fails to justify the photoelectric effect.
   (b) State the significance of the photoelectric effect experiment.
   (c) When a 546 nm light is used in a photoelectric experiment, the stopping potential is $0.38V$.
      i. Calculate the work function of the metal and the threshold wavelength.
      ii. Will electron be emitted if the target material is replaced with silver work function $4.73eV$? Justify your answer.

4. **[PSPM 14/15]**
   (a) Calculate the number of photon per second in a red laser beam with wavelength $700nm$ and $1mW$ power.
   (b) State TWO (2) features of the photoelectron which cannot be explained using the classical theory in a photoelectric experiment.
   (c) When light of wavelength 400 nm falls on a lithium surface in a photoelectric experiment, electrons having a maximum kinetic energy of 0.8 eV are emitted. Calculate the
      i. energy of the incident photon (in eV).
      ii. maximum speed of the electrons.
      iii. stopping potential of the surface.
      iv. work function of lithium(in eV).
      v. threshold frequency of lithium.

5. **[PSPM 15/16]**
   The figure below shows a photocell connected to a battery, ammeter, voltmeter and rheostat. The photocell is exposed to a monochromatic light of wavelength $275nm$.

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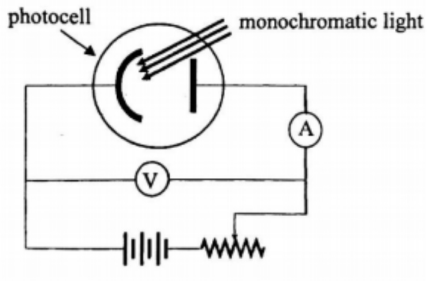

Initially, thereading of voltmeter is zero and the reading of voltmeter is zero and the reading of ammeter is $5nA$. The rheostat is adjusted until the ammeter reading reaches zero and the voltmeter reading is $-0.3V$.

(a) Sketch a graph of current flow in the circuit against the voltage across the photocell.

(b) Calculate the work function of photocell in eV.

(c) Calculate the threshold frequency of the photocell.

(d) The photocell is then exposed to monochromatic light of wavelength 320 nm. What is the ammeter reading? Explain your answer.

6. **[PSPM 16/17]**
Light of wavelength 500 nm is used in photoelectric experiment with caesium photocell. The work function of caesium is $2.14eV$. Calculate the

(a) threshold frequency of caesium

(b) maximum kinetic energy of the photoelectrons in Joule.

(c) stopping potential

7. **[PSPM 17/18]**

(a) State

i. the Plank's hypothesis of light.

ii. the duality of light.

(b) One of the advantages of an electron microscope is that we can see much finer details than an optical microscope. Explain how this is possible.

(c) When a monochromatic light of frequency $7.90 \times 10^{14} Hz$ incidents upon a metal surface, the stopping potential needed to terminate the emission of photoelectrons is $0.2V$. Calculate the work function and threshold frequency of the metal.

(d) The power of He-Ne Laser is $7.5mW$ and produces light of wavelength $633nm$. How many photons are emitted by the laser for 5 minutes?

8. **[PSPM 18/19]**

(a) In a photoelectric effect experiment, light of frequency $1.15 \times 10^{15} Hz$ strikes a metal surface and electrons are emitted immediately. The work function of the metal is $2.3eV$. Calculate the threshold frequency of the metal, maximum kinetic energy of the photoelectrons and the stopping potential of the photoelectrons.

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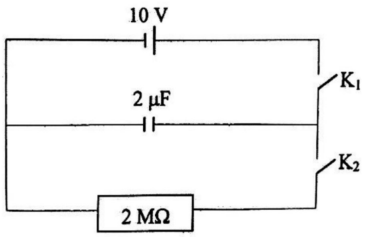
Chapter 2: Capacitors

Questions

1. **[PSPM 11/12]**

   (a) - N/A-

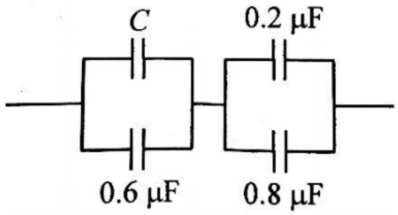
2. **[PSPM 12/13]**
   The figure below shows a $2\mu F$ capacitor connected to a $10V$ battery, a $2M\Omega$ resistor and switches K_1 and K_2.



   (a) Explain in words the meaning of capacitance.
   (b) Calculate the charge of the capacitor when switch K_1 is closed and switch K_2 is opened.
   (c) Switch K_1 is then opened and switch K_2 closed. Calculate the charge in the capacitor, $8.0s$ after K_2 is closed.

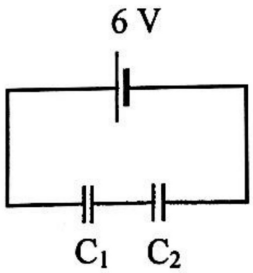
3. **[PSPM 13/14]**

   (a) Name a quantity that indicates how fast a capacitor is charging and discharging. State your reasoning.
   (b) Explain why inserting a dielectric between the plates of a capacitor increases its capacitance.
   (c) The figure below shows an arrangement of capacitors.



   If the equivalent capacitance is $0.5\mu F$, calculate the value of capacitor C.

4. **[PSPM 14/15]**
   The figure below shows two parallel plate capacitors C1 and C2 connected in series and fully charged by a $6V$ battery.



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The capacitors have the same plate area and are filled with similar dielectric material. The distance of separation of the plates for C1 and C2 are $2mm$ and $4mm$ respectively.

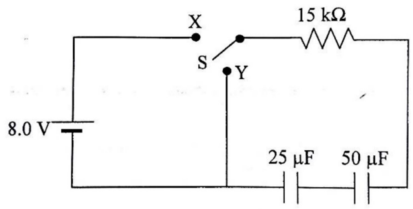
(a) Calculate the potential difference across capacitor C2.

5. **[PSPM 15/16]**
A parallel plate capacitor of $47\mu F$ is charge by a $12V$ battery. The battery is disconnected after the capacitor is fully charged.

(a) Calculate the charge on the plate.

(b) What will happen to the potential difference between the plates if the distance between plates is doubled? Justify your answer.

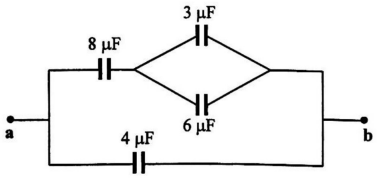
6. **[PSPM 16/17]**
The figure below shows two fully discharged capacitors, $25\mu F$ and $50\mu F$ are connected in series with a $15k\Omega$ resistor. The capacitors are charge when switch S is closed at X.



(a) What is the time constant of the charging circuit?

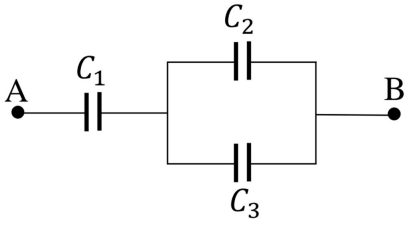
(b) Switch S is closed at Y after the capacitors are fully charged. What is the initial current in the circuit?

7. **[PSPM 17/18]**
The figure shows a circuit consists of four capacitors.



(a) Calculate the equivalent capacitance between terminals a and b.

8. **[PSPM 18/19]**



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The figure shows three capacitors C_1 , C_2 and C_3 each $12\mu F$ connected between points A and B.

(a) Calculate effective capacitance.

(b) If the potential difference across AB is $9V$, calculate the stored energy.

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Chapter 10: Matter Waves

Questions

1. **[PSPM 11/12]**

   (a) Name one experiment that verifies the wave nature of electron.

   (b) An electron has a de Broglie wavelength 2×10^{-11}. Calculate the momentum of the electron and the the speed of the electron.

2. **[PSPM 12/13]**

   (a) State de Broglie hypothesis.

   (b) In an experiment, an electron is accelerated from rest through a potential difference of $3MV$. Determine de Broglie wavelength, the momentum and kinetic energy of the electrons.

3. **[PSPM 13/14]**

   (a) When a 546 nm light is used in a photoelectric experiment, the stopping potential is $0.38V$. Calculate the minimum de Broglie wavelength of the electron.

   (b) State ONE advantage of the electron microscope compared to the

4. **[PSPM 14/15]**

   (a) State the de Broglie relation for momentum of a particle with its associated wavelength.

   (b) An athlete of mass 65 kg takes 12 s to finish a 100 m race ia a sport event. Calculate the de Broglie wavelength of the athlete.

5. **[PSPM 15/16]**
   In Davidson – Germer experiment, an electron is accelerated from rest through a potential difference of $2500V$ and the diffraction pattern is observed on the tube screen.

   (a) Calculate the de- Broglie wavelength of electron.

   (b) Calculate the momentum of electron

   (c) If the potential difference is increased up to 3000 V, what happen to the diffraction pattern? Explain your answer.

6. **[PSPM 16/17]**
   The energy of a photon and the kinetic energy of an electron is the same in vacuum, that is $6.0eV$.

   (a) What is the velocity and the wavelength of the photon?

   (b) Obtain the wavelength associated with the electron.

7. **[PSPM 17/18]**

   (a) -N/A-

8. **[PSPM 18/19]**

   (a) Calculate the speed of a neutron with de Broglie wavelength $9 \times 10^{-11}m$.

   (b) Calculate the wavelength of an electron that has been accelerated across a potential difference of $100V$.