Tutorial Questions

Contents

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1 Chapter 1: Electrostatics

Coulomb's Law

1. Calculate the Coulomb force between a charged particle of $2\mu C$ and another particle of $5\mu C$. Is it repulsive or attractive? Sketch the situation described and label the Coulomb forces on each particle.

2. Three point charges are placed at the following points on the x-axis: $+2\mu C$ at $x = 0$, $-3\mu C$ at $x = 40cm$, $-5\mu C$ at $x = 120cm$. Find the force on the $-3\mu C$ charge.

3. Consider two charges of $4\mu C$ and $3\mu C$ that are placed such that the separation between them is $1m$. Where, between the two aforementioned charges, should a third charge of $-2\mu C$ be placed so that it experiences zero net Coulomb force.

4. Three charges are placed on the vertices of an equiliateral triangle with sides 2m. If the charges are $2\mu C$, $-2\mu C$ and $3\mu C$, calculate the net force (and its direction) on a test charge if the test charge is placed in the middle of the triangle.

5. Four point charges are placed on the corners of a square that is $25cm$ on its side. The charge on the top right is $3\mu C$, the top left, $-2\mu C$, bottom left, $1.5\mu C$ and the charge on the bottom right to be $-2\mu C$. Calculate the net force exerted on the $-2\mu C$ by the three other charges.

Electric Field

1. Calculate the electric field at a distance of $0.2m$ from a charge of $3nC$.

2. A point charge of $2\mu C$ is placed at the origin of coordinates. Calculate the electric field at $(x, y) = (3, 4)m$.

3. Point charges $2\mu C$, $-5\mu C$ and $+8\mu C$ are placed at coordinates $(-1, 2)cm$, $(2, 2)cm$ and $(1.5, -3)cm$ respectively. Calculate the electric field at the origin. Calculate the force exerted on a charge of $0.5\mu C$ if it were to be placed on the origin.

4. Four point charges are placed on the corners of a square that is $20cm$ on its side. The charge on the top right is $3\mu C$, the top left, $-2\mu C$, bottom left, $1.5\mu C$ and the charge on the bottom right to be $-2\mu C$. Calculate the net electric field at the centre of the square.

5. *Three parts:

   (a) Consider two particles of charges $2\mu C$ and $-2\mu C$ placed on coordinates $(0, -1)m$ and $(0, 1)m$ respectively. Calculate the electric field at coordinate $(5, 0)m$ and $(20, 0)m$.

   (b) Now consider if instead we placed a single $4\mu C$ at the origin, calculate the electric field at coordinate $(5, 0)m$ and $(20, 0)m$.

   (c) Compare the numerical values for part (a) and (b). Comment on your results.

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Electrical Potential

1. What is the electric potential at $0.5m$ from a $40\mu C$ point charge?
2. The work done in bringing a charge of $20\mu C$ from infinity to a point in an area of electric field is $3 \times 10^4 J$. What is the electric potential at that point?
3. A hollow sphere has a radius of $2cm$ and contains a charge of $5\mu C$. Assuming this sphere to be isolated, calculate the potential at a distance of $75cm$ from the centre of the sphere.
4. Three equal point charges of $3\mu C$ are placed at three corners of a square of sides $20cm$. Find the electrical potential at the fourth corner of the square.
5. Two point charges X and Y of charge $3.5\mu C$ and $2\mu C$ respectively are placed $15cm$ from each other. Calculate the work done to move charge Y to $3cm$ nearer to charge X.

Charge in Uniform $\vec{E}$

1. 2 plate arrange parallel to each other are spaced $0.6cm$ apart. They are connected to a 90V battery. Find the electric field between them.
2. In the Milikan experiment, an oil drop carries 3 electronic charges and has a mass of $1.35 \times 10^{-12} g$. This oil drop is held at rest between two horizontal charged plates $1.8cm$ apart. What voltage must there be between the two charged plates to keep the oil drop at rest?
3. A proton is accelerated from rest through a potential difference of $1kV$. What is its final speed?
4. An electron moves from plate A (of electrical potential $-60V$) to plate B (of electrical potential $+50V$). Assuming the system is in vacuum, what is the speed of the electron just before it hits plate B?
5. An electron enters a region of electric field generated by two parallel plates of potential difference $150V$, with a plate separation of $50mm$. The length of the parallel plates is 65mm. If the electron enters the region with velocity $9 \times 10^6 ms^{-1}$, Calculate the
   (a) the acceleration of the electron in its vertical axis [Ans: $5.3 \times 10^{14} ms^{-2}$]
   (b) the time for which the electron travels through the region of electric field [Ans: $7.2 \times 10^{-9} s$]
   (c) the deviation of the electron upon exiting, from its original path [Ans: $1.37 \times 10^{-2} m$]
   (d) the velocity of the electron in its vertical axis as it exits the electric field [Ans: $3.8 \times 10^6 ms^{-1}$]

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2 Chapter 2: Capacitors

Capacitance in series and parallel

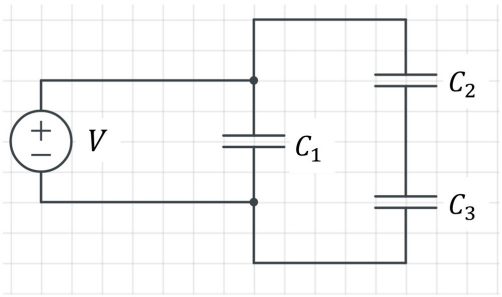
$\boxed{C = \frac{Q}{V};\ U = \frac{1}{2}QV}$

1. When the potential difference is $1kV$, the two plates of a capacitor hold $+4000\mu C$ and $-4000\mu C$ of charge respectively. What is the capacitance of this capacitor? Calculate the energy stored in the capacitor.

2. What is the voltage across a capacitor which has the capacitance of $12000\,pF$ and when fully charged, holds $24 \times 10^{-8}\,C$ of charge?

3. When the voltage across a capacitor is increased from $35V$ to $50V$, the charge of the capacitor was found to have increased from $30\mu C$ to $60\mu C$. Calculate the capacitance of the capacitor and the energy change.

4. In the figure below, suppose $C_i = \{10\mu, 12\mu, 8\mu\}F$.



   Calculate the equivalent capacitance of the circuit.

5. Referring to question 4, what would the voltage across each capacitor be if $C_i = \{2\mu, 3\mu, 4\mu\}F$ and $V = 26V$?

Capacitors Charging and Discharging

$\boxed{\tau = RC;\ Q = Q_o e^{-\frac{t}{RC}};\ Q = Q_o(1 - e^{-\frac{t}{RC}})}$

1. Calculate the time constant τ for an RC circuit with a $1k\Omega$ resistor and a $4000\mu F$ capacitor.

2. In the RC circuit, the capacitor initially has a charge of $20\mu C$. Calculate the charge in the capacitor after $8s$, if the time constant for the circuit is $4s$.

3. Calculate the time needed to charge capacitors the circuit below to 50% full.

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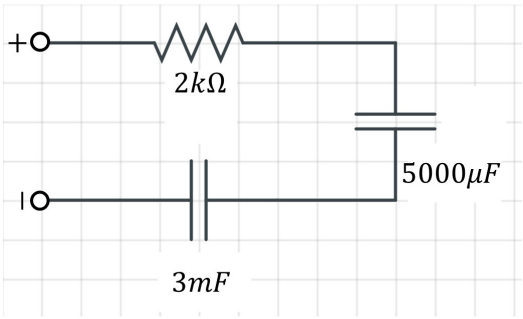

Capacitors with dielectrics

$\varepsilon_r = \frac{\varepsilon}{\varepsilon_o}$; $C_o = \frac{\varepsilon_o A}{d}$; $C = \varepsilon_r C_o$

1. What is the capacitance of a pair of circular plates with a radius of $2.5cm$ separated by $3mm$ of mica, that has a dielectric constant of 6.
2. A $4000pF$ air-gap capacitor is supplied with $24V$. Calculate the charge flow after a dielectric material of dielectric constant 3 is added between the plates.

3 Chapter 3: DC circuits

Electric Conduction, Resistivity & Ohm's Law

1. A current of $8A$ is maintained in a conductor for $30s$. How much charge has flowed through the conductor in this time ?
2. Calculate the magnitude of current if 3×10^{23} electrons has flowed through a conductor in $32\,minutes$.
3. Calculate the resistance of a copper resistor of $30m$ long and $0.3mm$ diameter, assuming the resistivity of copper is $1.7 \times 10^{-8}\,\Omega\,m$.
4. What is the potential difference that is required to pass $5A$ through 30Ω?
5. A electric conductor tube has an inner tube diameter of $0.7cm$ and an outer diameter of $1cm$. Find the electric resistance if it has the length of $30cm$ and resistivity of $10^{-7}\Omega m$.

Resistance Variation with Temperature

1. Based on the table below, calculate the resistance at temperature T_f for each of the following cases:

Question	R_i	T_f	T_i	α
a	200Ω	$47K$	$22K$	0.004041^oC^{-1}
b	$15k\Omega$	$5K$	$20K$	0.005671^oC^{-1}
c	100Ω	15^oC	$293.15K$	0.003715^oC^{-1}

a

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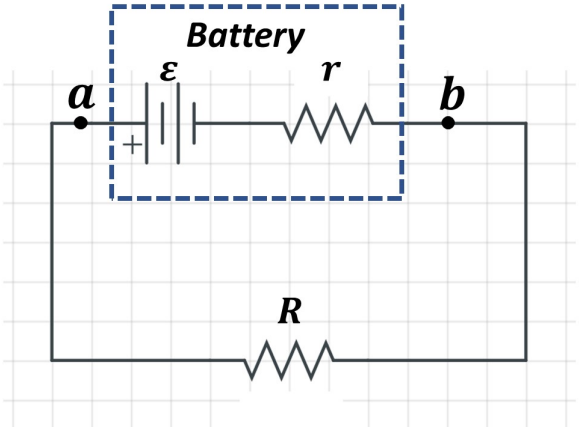
2. Calculate temperature at which conductor has the resistance of 200Ω if the conductor has a thermal coefficient of resistance 0.0038^oC^{-1} and has a resistance of 150Ω at 50^oC.

Electromotive Force, Series and Parallel Circuit

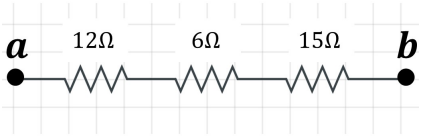
1. The figure below shows a simple circuit consisting of a battery and a resistor.



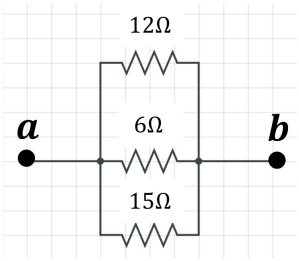
If the electromotive force of the battery is $9V$, the battery has an internal resistance of 0.5Ω and the resistor has a resistance of 6Ω, calculate the potential difference between points a and b.

2. Calculate the effective resistance between points a and b for each of the following diagram:

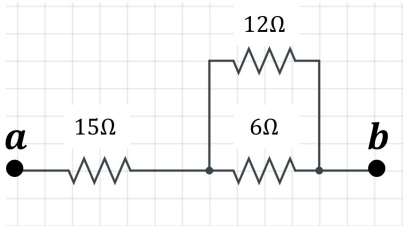
a) Case 1:



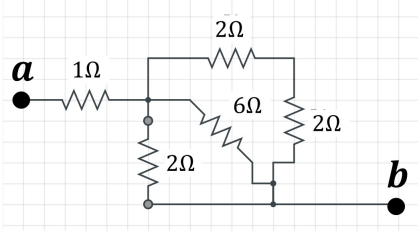
b) Case 2:



c) Case 3:



d) Case 4:



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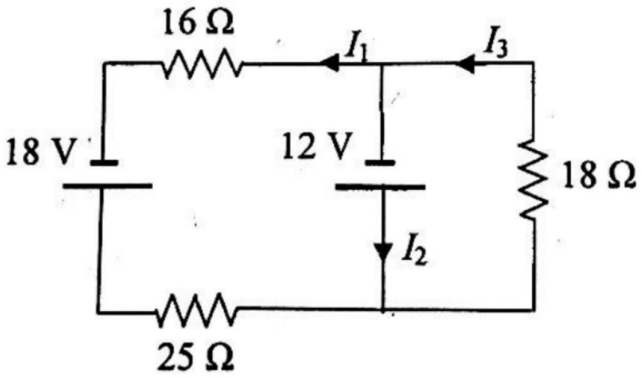
Kirchhoff's Law

1. Calculate the values for x and y for the following pair of linear equations:

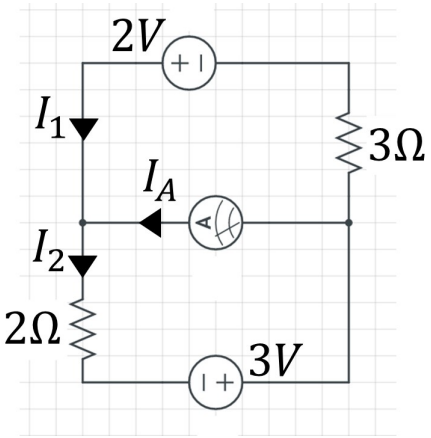
a)	$2x - 2y = 18$ $5x - 4y = 42$	b)	$4x = 14 + 2y$ $5y = 5x - 25$
c)	$x + 4y = 35$ $4x + 4y = 44$	d)	$x = 14 + y$ $4y = 4 - 3x$

2. **[PSPM 2014/2015]** The following diagram shows circuit consisting of 3 resistors and 2 emf.



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

3. **[PSPM 2016/2017]** The following diagram shows circuit consisting of 2 batteries, 2 resistors and an ammeter.



If the ammeter has internal resistance of 5Ω, what is the reading shows by the ammeter?

4. **[PSPM 2017/2018]** The following diagram shows circuit consisting of 2 batteries and 3 resistors.

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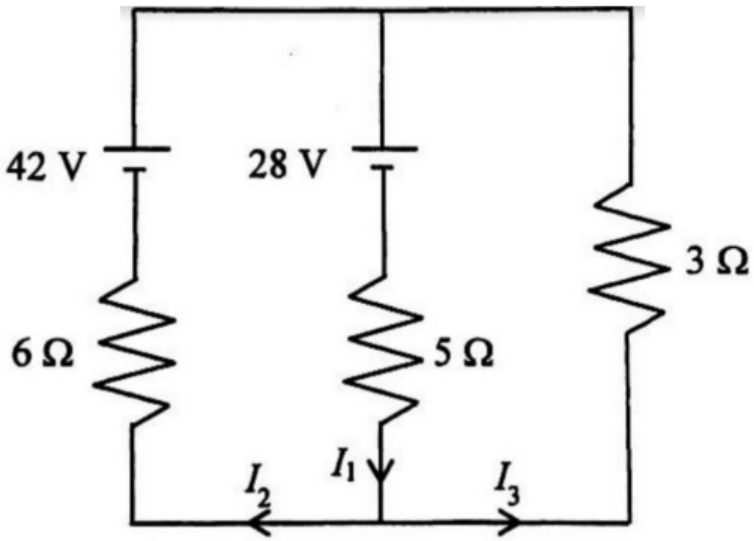
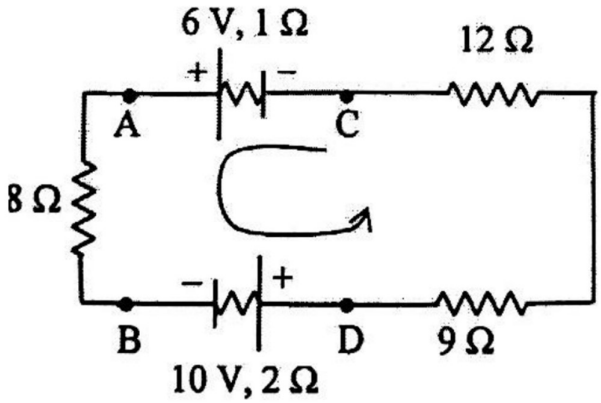


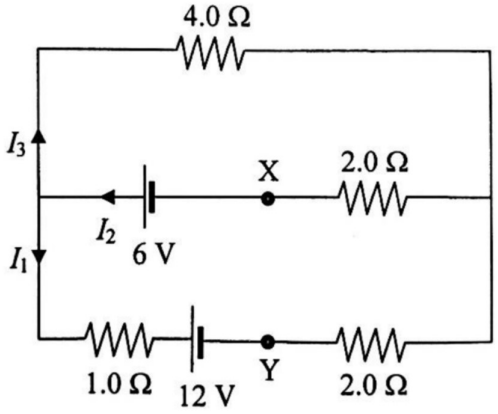
Calculate currents I_1, I_2 and I_3.

5. [**PSPM 2012/2013**] The following diagram shows circuit consisting of 2 batteries and 3 resistors.



By using the anticlockwise loop as shown, calculate the current that flows through the 8Ω resistor and the potential difference across point A and C, V_{AC}.

6. [**PSPM 2011/2012**] The following diagram shows circuit consisting of 2 batteries and 3 resistors.



(a) Calculate I_1, I_2 and I_3.

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(b) Calculate the potential difference between points X and Y.

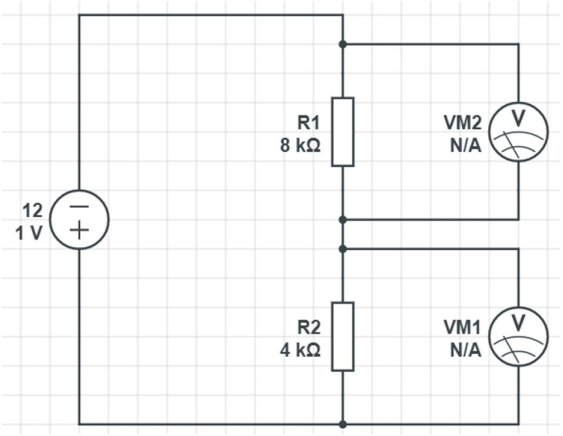
(c) Calculate the total power dissipated in the circuit.

Electrical Energy and Power

1. A 200Ω resistor has a current of $0.5A$ running through it, calculate the power lost through the resistor.
2. A bulb rated $120V/90W$ is operated from a 120V-source. Find the current running through it and the resistance of the bulb.
3. What is the resistance of a $1000W$ toaster running at $120V$? Calculate the heat energy dissipated if it was left running continuously for 2 minutes.

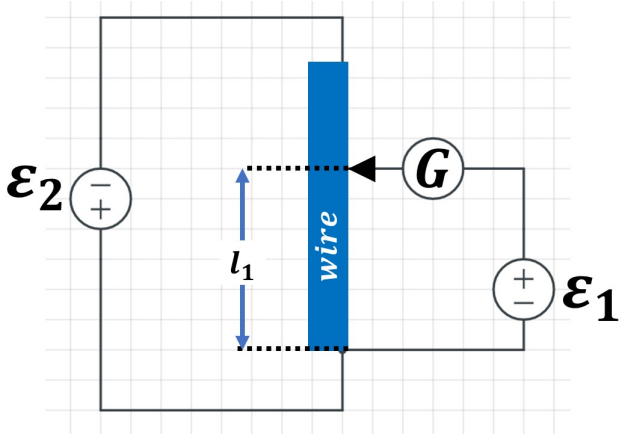
Potential Divider & Potentiometer

1. The following diagram shows circuit consisting of 1 battery, 2 voltmeters and 2 resistors.



Calculate the voltmeter readings.

2. The diagram below shows a potentiometer setup.



When $\varepsilon_2 = 1.5V$, the gavanometer gives a zero reading at $l_1 = 25cm$. What is the emf of ε_2 if the galvanometer gives a zero reading when $l_1 = 45cm$?

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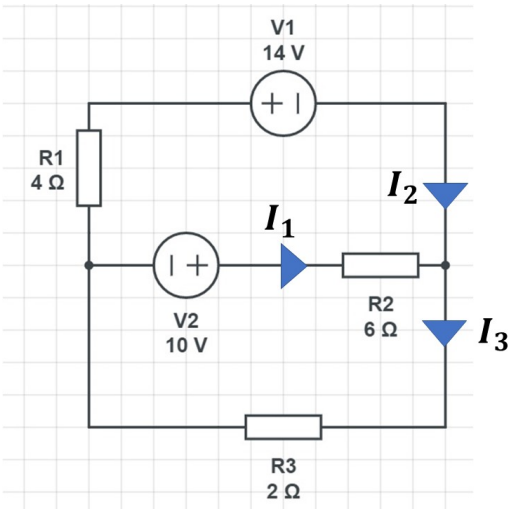
Extras

1. A wire $50m$ long and $2mm$ in diameter is connected to a source with a potential difference $9.11V$ and the current was found to be $36A$. Identify the metal out of which the wire is made out of.

2. Aluminium and copper wires of equal length are found to have the same resistance, what is the ratio of their radii?

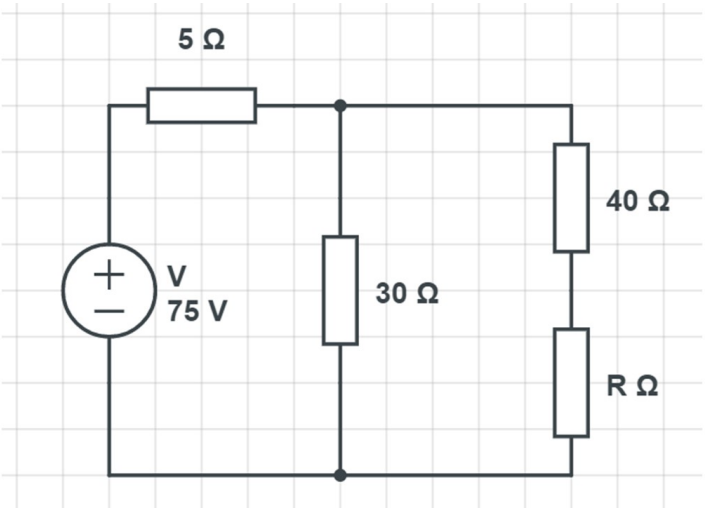
3. Calculate I_1, I_2 and I_3 in the figure below.



4. For $\tau = RC$, show that τ has units of time using Ohm's Law.

5. A lamp ($R = 150\Omega$), an electric heater ($R = 25\Omega$) and a fan ($R = 50\Omega$) are connected in parallel across a $120 - V$ line.
   Calculate the total current supplied to the circuit and the power expended by the heater.

6. The resistor R dissipates $20W$ of power, determine the value of R.



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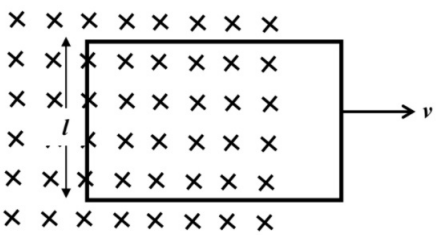
4 Chapter 5: Electromagnetic Induction

Magnetic Flux & Induced emf

1. State the definition and the SI unit of magnetic flux $\phi_{magnetic}$.
2. What is the difference between magnetic field strength and magnetic flux?
3. A quarter loop of area $15cm^2$ is placed in a region of magnetic field $0.16T$. Calculate the magnetic flux if the angle between the quarter loop area and the magnetic field is
   (a) 90^o
   (b) 70^o
   (c) 30^o
4. A loop of wire of area $40cm^2$ is placed in a magnetic field of strength $2cT$. Calculate the angle between the magnetic field and the wire loop if the magnetic flux is
   (a) $80\,\mu Wb$
   (b) $69\,\mu Wb$
   (c) $56\,\mu Wb$
5. A solenoid of cross-sectional area $60cm^2$ is placed in a magnetic field of strength $5cT$. The cross-sectional area of th solenoid is kept perpendicular to the magnetic field, and it was found that the magnetic flux to be $0.9Wb$. Calculate the number of turns found in the solenoid.
6. A circular coil of wire (of N turns, radius r) is placed in a magnetic field of strength B. The number of turns is then doubled, at what angle (between the magnetic field and cross-sectional area of solenoid) would the magnetic flux of the new solenoid be the same as the old solenoid (before it was doubled in number of turns)?
7. $2A$ current is flowed through a solenoid(of 10000 winding per metre, $80mm$ radius). Calculate the flux through the solenoid.
8. A magnetic field perpendicular to a circular coil (18 turns, radius $50mm$) changes from $2T$ to $20T$ in $3s$, Calculate the magnitude of the induced emf.
9. $3A$ current is flowed through a solenoid(of 5000 winding per metre, $60mm$ radius, $3cm$ length). Calculate the induced emf if the magnetic flux through it is increased by $1mWb$ in $240ms$.
10. The figure below shows a rectangular coil of 40 turns and length $l = 20cm$. It is pulled in a uniform magnetic field $B = 2T$



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Calculate the magnitude and direction of the induced emf in the wire if the electrical resitance of the wire is $R = 5\Omega$ and the coil is pulled with a speed of $v = 20cm\,s^{-1}$.

11. An AC generator consisting a 30 turn coil with cross sectional area of $0.1m^2$ and resistance of 100Ω. The coild rotates in a magnetic field of strength $0.5T$ at a frequency of $30Hz$. Calculate the maximum induced current.

Self-Inductance

1. What is **self-inductance**? Explain the process.
2. Induced emf of $6V$ is developed across a coil when the current flowing through it changes at $30As^{-1}$. Determine the self-inductance of the coil.
3. If the current in a $230mH$ changes steadily from $20mA$ to $28mA$ in $140ms$. What is the induced emf?
4. Calculate the value of self-inductance for an air filled solenoid of length $5cm$ and cross-sectional area of $0.3cm^2$ containing 50 loops.
5. Suppose you wish to make a solenoid with a self inductance of $1.5mH$. Due to certain commercial constraints, it is imperative that the inductor must have a cross-sectional area of $2.2 \times 10^{-3}m^2$ and a length of $10cm$. How long of a wire would you need to make this solenoid?
6. A 500turns of solenoid is $8cm$ long. When the current in the solenoid is increased by $2.5A$ in $0.35s$, the magnitude of the induced emf is $0.012V$. Calculate the inductance of the solenoid and the cross sectional area of the solenoid.

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Inductor-stored Energy & Mutual Inductance

1. Two coils, X & Y are magnetically coupled. The emf induced in coil Y is $2.5V$ when the current flowing through coil X changes at the rate of $5As^{-1}$. Determine the mutual inductance of the coils and the emf induced in coil X if there is a current flowing through coil Y which changes at the rate of $1.5As^{-1}$.

2. The magnetic fild inside an air-filled solenoid $36cm$ long and $2cm$ in diameter is $0.85T$. Approximately how much energy is stored in this field?

3. A coil has an inductance 45 mH and resistance 0.3Ω. An emf of $12V$ is applied to the coil until equilibrium current is achieved. Calculate the energy stored in the coil.

4. A current of 5.0 A 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 the energy stored in the solenoid.

5. An electric current of $1.5A$ flowing through a coil P produces a total magnetic flux of $0.540Wb$ in the coil. If a coil Q is brought near coil P, the total magnetic flux of 0.144 Wb is produced in coil Q.

   (a) Calculate the self—inductance of coil P, and determine the energy stored in coil P before coil Q is brought near it.

   (b) Calculate the mutual inductance of coil P with coil Q.

   (c) If the current in coil P is reduced uniformly from $1.5A$ to $0A$ in $0.3s$, determine the induced e.m.f of coil Q.

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

7. A current of $3.0A$ flows in coil C and is produced a magnetic flux of 0.75 Wb in it. When a coil D is moved near to coil C coaxially, a flux of $0.25Wb$ is produced in coil D. If coil C has 1000 turns and coil D has 5000 turns.

   (a) Calculate self-inductance of coil C and the energy stored in C before D is moved near to it

   (b) Calculate the mutual inductance of the coils

   (c) If the current in C decreasing uniformly from $3.0A$ to zero in $0.25s$, calculate the induced emf in coil D.

5 Chapter 6: AC circuits

Question:

6.1 AC & 6.2 RMS

$V = V_{peak}\, sin\,(\omega t)$; $I = I_{peak}\, sin\,(\omega t)$; $V_{rms} = \frac{V_{peak}}{\sqrt{2}}$; $I_{rms} = \frac{I_{peak}}{\sqrt{2}}$

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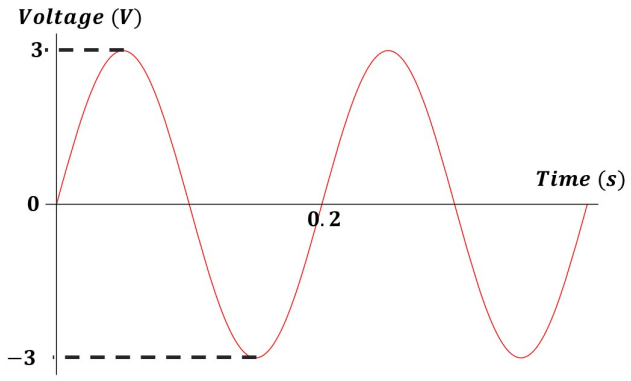
1. The voltage generated by a generator is as shown in the graph below.



   (a) What is the peak voltage, peak-to-peak voltage and the rms voltage?

   (b) The voltage is connected across a resistor with a resistance 2.5Ω. Calculate the peak, rms current and average power.

2. For the following situation, sketch the waveform and write down the equation for

   (a) voltage as a function of time with frequency $50Hz$ and peak voltage of $2V$.

   (b) voltage as a function of time with period of $20s$. and peak-to-peak voltage of $2V$.

3. A sinusoidal, $60.0Hz$, ac voltage is read to be $120V$ by an ordinary voltmeter. What is the equation for the voltage ? Sketch the waveform.

4. A voltage $V = 60sin120\pi t$ is applied across a 20Ω resistor. Calculate the reading on the ac ammeter and the average power.

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6.3: Resistance, Reactance & Impedance
6.4: Power Factor

$X_C = \frac{1}{2\pi fC}$; $X_L = 2\pi fL$; $Z = \sqrt{R^2 + (X_L - X_C)^2}$; $\phi = tan^{-1}\left(\frac{X_L - X_C}{R}\right)$; $P_{ave} = I_{rms}V_{rms}cos\,\phi$; $P = IV$; $cos\phi = \frac{P_{real}}{P_{apparent}} = \frac{P_{real}}{I^2Z} = \frac{R}{Z} = \frac{P_{ave}}{IV}$;

1. $R-$ **circuit:**
   A purely resistive circuit consist of a resistor rated $120V$, $1200W$ and an AC of frequency $100Hz$. Calculate the current drawn, the maximum value of current and the resistance in the dryer.

2. $L-$ **circuit:**
   A circuit contains a $400mH$ inductor and a resistor of 0.5Ω connected to an AC power supply of $80V$ at the frequency of $100Hz$. Determine the reactance of the inductor. How does it compare to the resistance of the resistor? Calculate the rms current and the maximum current.

3. $C-$ circuit:
   A $50\mu F$ capacitor is connecte across the terminals of an AC power supply, of which has a sinusoidal output of $50Hz$ with maximum voltage of $100V$. Determine the rms current and maximum current in the circuit.

4. $RL-$ circuit:
   A coil has an inductance of $0.1H$ and a resistance of 12Ω. Together with a resistor of 10Ω, it is connected (in series) to a $110V$, $60Hz$ line.
   Determine

   (a) the reactance of the coil
   (b) the impedance of the coil
   (c) the current in the circuit
   (d) the power factor of the circuit
   (e) the phase angle between current and supply voltage
   (f) the wattmeter reading in the circuit.

5. $RC-$ circuit:
   A $10\mu F$ capacitor is in series with a 40Ω resistance and the combination is connected to a $110V$, $60Hz$ line.
   Calculate

   (a) the capacitive reactance
   (b) the impedance of the coil
   (c) the current in the circuit
   (d) the power factor of the circuits
   (e) the phase angle between current and supply voltage

6. $RLC-$ circuit - Potential Difference:
   A circuit has a resistance of 11Ω, a coil of inductive reactance 120Ω and a capacitor of 100Ω, all connected in series with $110V, 60Hz$ power source. What is the potential difference across each circuit element.

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7. $RLC-$ circuit - Resonance Frequency:
   The impedance of a series $RLC-$circuit is 8Ω when frequency $f = 60Hz$ at resonance and 10Ω at $80Hz$. Calculate the values of L and C.

6 Chapter 7: Optics

Questions:

Reflection at a spherical surface

$$R = 2f$$

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$M = \frac{h_i}{h_o} = -\frac{v}{u}$$

Sign convention:

Quantity	+	−
u	left of vertex, real object	right of vertex, virtual object
v	left of vertex, real Image	right of vertex, virtual image
f	Concave mirror	Convex mirror

1. A convex mirror has a radius of curvature of $0.2m$, what is the focal length?

2. An object $200cm$ from the vertex of a spherical concave mirror is imaged $400cm$ in front of the mirror, what is the focal length of the mirror?

3. A display lamp having a bright $5cm$ long vertical filament is positioned $30cm$ from a concave mirror that projects the bulb's image onto a wall $9m$ from the vertex. What is the radius of curvature of the mirror? How big is the image?

4. An object $10cm$ high is $50cm$ from a concave mirror of $20cm$ focal length. Find the image distance, height and direction.

   Image is real, $\frac{1}{15}m$ high and inverted.

5. How far should an object be from a concave spherical mirror of radius $45cm$ to form a real image one-ninth it size?

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Refraction at a spherical surface

$$\frac{n_1}{u} + \frac{n_2}{v} = \frac{n_2 - n_1}{R}$$

Sign convention:

Quantity	+	−
u	Real	Virtual
v	Real	Virtual
r	Convex surface	Concave surface

1. A cylindrical glass rod in air has a refractive index of 1.52. One end is ground to a hemispherical surface with radius, $r = 3.00cm$. Calculate the position of the image for a small object on the axis of the rod, $10.0cm$ to the curved end of the pole.

2. A small fish is $4cm$ from the far side of a spherical fish bowl $25cm$ in diameter. Ignoring the effects of the glass walls of the bowl, where does the observer see the image of the fish if the refractive index of water is 1.33?

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Thin lenses

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$\frac{1}{f} = \left(\frac{n_{material}}{n_{medium}} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$m = \frac{h_i}{h_o} = -\frac{v}{u}$$

Sign convention:

Thin lenses		
Quantity	+	−
u	real object	virtual object
v	real Image	virtual image
f	Convex/converging lens	Concave/diverging lens
lensmaker's equation		
Quantity	+	−
R_1	convex	concave
R_2	concave	convex

Thin lens equation

1. An object is placed $x - cm$ from a thin lens with a $10cm-$focal length. Find the position of the image if
   (a) $x = 30cm$ and the lens is converging
   (b) $x = 30cm$ and the lens is diverging
   (c) $x = 5cm$ and the lens is converging
   (d) $x = 5cm$ and the lens is diverging
2. A $6cm$-high object is placed $30cm$ from a converging lens and its image forms $90cm$ from the lens and on the same side as the object. What is the focal length of the lens?
3. Calculate the position and focal length of a conveging lens which will project the image of an object with a magnification of 4, upon a screen $10m$ from the object.

Lensmakers' equation

1. A lens (made out of glass of refractive index 1.54) has a convex surface of radius $20cm$ and a concave surface of radius $40cm$. Calculate the focal length and deduce if the lens is converging or diverging.
2. A parallel beam of white light strikes a biconvex lens having faces of radii $32cm$ and $48cm$. The refractive indices of the glass for the A(red) and H (violet) spectral lines are 1.578 and 1.614 respectively. Calculate the distance between the focal points of red and violet radiations.
3. A double convex glass has faces of radii $18cm$ and $20cm$. Calculate the
   (a) focal length of the lens when an image is formed $32cm$ from the lens if the object is placed $24cm$ away from the lens.

(b) refractive index of the lens.

4. A symmetric lens with a focal length of $5cm$ is made of a material of refraction index 1.5. Calculate the refractive index of each surface of the lens?

Questions:

Huygens' Principle & Wave Interferences

1. State Huygen's Principle and its application on light wave analysis.
2. Show (either diagrammatically or in forms of equation) that the laws of reflection and refraction can be verified using Huygen's wave theory.
3. What type of wave front will emerge from a point source and a distance light source?
4. Explain the application of Huygen's Principle in the case of a single slit.
5. When are two light sources of the same common frequency said to be coherent ?
6. What are the conditions for the interference of light?
7. From a path difference perspective, state the condition for constructive and destructive interference.

Young's Double Slit Experiment

1. The interference pattern of two identical slits separated by a distance $d = 0.25mm$ is observed on a screen at a distance of $0.5m$ from the plane of the slits. The illuminating light source has a wavelength of $589nm$. Calculate the distance of the first bright fringe to the central maximum, and the separation of the bright bands.
2. Light (of $589nm$) from a lamp forms an interference pattern on a screen $0.75m$ from a pair of slits. The bright fringes in the pattern are $0.4cm$ apart. Calculate the slit separation.
3. A laser light of $630nm$ incident on a pair of slits produces an interference pattern in which the bright fringes are separated by $8.3mm$. A second light, on the other hand, produces an interference pattern of which its dark fringes are separated by $7.6mm$. Calculate the wavelength of the second light.
4. Light from two light sources (of wavelengths λ_1 and λ_2 respectively) arrives at a double slit set up. If $\lambda_1 = 430nm$, what value must λ_2 be if the fourth order bright fringe of light with $\lambda_1 = 645nm$ overlaps with the sixth order bright fringe of λ_2 light?
5. In a double-slit experiment with light source $700nm$, a student is limited to a $70cm$ white-coloured cardboard sheet as a screen. Assuming intensity is not a limiting factor, calculate the highest order of bright fringe the student will be able to observe if the slit separation is $0.02mm$.

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Thin Films

Media	phase change	Constructive Interference
$n_{1^{st}} > n_{2^{nd}} > n_{3^{rd}}$ or $n_{1^{st}} < n_{2^{nd}} < n_{3^{rd}}$	$0\,rad$	$2nt = m\lambda$
$n_{1^{st}} > n_{2^{nd}} < n_{3^{rd}}$ or $n_{1^{st}} < n_{2^{nd}} > n_{3^{rd}}$	$\pi\,rad$	$2nt = (m + 0.5)\lambda$

1. A soap film has a refractive index of 1.33. How thick is the film if one-half of a wavelength of red light (with a vacuum wavelength of $633nm$) extends from on surface to the other surface?

2. A thin film of alcohol ($n_{alcohol} = 1.36$) spread on a flat glass plate and is illuminated with white light. If a region of the film reflects only green light ($\lambda_{green} = 500nm$) strongly, how thick is the film?

3. A glass lens with an index of 1.55 is to be coated with a film of index 1.30 to decrease the reflection normally incident green light of $\lambda = 500nm$. What minimum thickness should be deposited on the lens?

4. A film of oil ($n_{oil} = 1.42$) of $250nm$ thick floats on water. When illuminated from above with white light, what colour will reflect the most brightly?

5. A soap film of index 1.35 appears yellow ($580nm$) when viewed directly from above. Compute several possible values of its thickness.

Single Slit Diffraction

$$y_n = \frac{n\lambda D}{a} \text{ for dark fringes}$$

$$y_n = \frac{(n + 0.5)\lambda D}{a} \text{ for bright fringes}$$

1. A soap film has a refractive index of 1.33. How thick is the film if one and a half of a wavelength of red light (with a vacuum wavelength of $633nm$) extends from on surface to the other surface?

2. If the separation between the first and the second minima of a single-slit diffraction pattern is $6.0mm$, what is the distance between the screen and the slit? The light wavelength is $500nm$ and the slit width is $0.16mm$.

3. When a single slit of width $0.3mm$ is illuminated with light of wavelength is $633nm$, the distance from the central maximum of the 1^{st} order minimum is $4cm$. Calculate this distance if the slit is doubled.

4. A single slit $0.1mm$ wide is illuminated by plane waves from a HeNe laser ($\lambda = 633nm$). If the screen is $10m$, determine the width of the central maximum.

5. A vertical single slit is illuminated with electromagnetic wave from a HeNe laser at $633nm$. It is found that the center of the second dark band lies at an angle of 4.2^o off the central axis. Determine the width of the slit.

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Diffraction Grating

$$d\,sin\,\theta = n\lambda;\ d = \frac{1}{N}$$

1. A screen is placed $1.4m$ away from a diffraction grating illuminated with light of wavelength $633nm$. If the second- and third-order spectra are to be separated by $1.5cm$ on the screen, how many lines per centimetre are needed for the grating?
2. When a grating is illuminated with light of $\lambda = 540nm$, only 3 lines on either side of the central maximum can be seen. Calculate the maximum number of lines for the grating.
3. A gas discharge tube emits electromagnetic radiation of wavelengths $660nm$ and $430nm$ that illuminates a diffraction grating of 4000 lines cm^{-1}. Calculate the angular separation between the first order maximas of both wavelengths.

7 Chapter 8: Wave Properties of Particle

Questions:

de Broglie Wavelength

$$\lambda = \frac{h}{p}$$

1. What is the idea of "wave-particle duality" of light?
2. What do we mean when we say a particle may exhibit wave-like nature?
3. If we say particles has wave light properties, how then can we characterise it's wavelike nature?
4. Calculate the de Broglie wavelength of a $0.5kg$ ball moving with a speed $20ms^{-1}$.
5. Calculate the wavelength of an electron accelerated with a potential difference of $100V$.
6. Find the de Broglie wavelength for a particle of mass $1.67 \times 10^{-27}kg$ travelling at $1100ms^{-1}$.
7. If the de Broglie wavelength of an electron is 0.5Å(Angstrom), calculate its kinetic energy.

Electron Diffraction

1. What is Bragg's Law?
2. Describe the results of the Davisson-Germer Experiment and its significance.
3. Describe the mechanism behind an electron microscope.
4. How does the de Broglie's wavelength relate to the resolving power of an electron microscope?
5. In a table, compare and contrast between electron microscope and optical microscope.

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8 Chapter 9: Nuclear & Particle Physics

Questions:

Binding Energy & mass defect

$$1amu = 1.6605 \times 10^{-27} kg = 931.49432 MeV\, c^{-2}$$

$$\Delta m = Z m_p + N m_n - m_{nucleus}$$

$$E_{binding} = \Delta m c^2$$

1. Define the following term:
   (a) mass defect
   (b) binding energy

2. How many protons and neurons are in
   (a) $^{24}_{11}Na$
   (b) $^{6}_{3}Li$
   (c) $^{206}_{82}Pb$

3. Both in atomic mass unit and in kilogram, calculate the mass defect, the binding energy and the binding energy per nucleon for the following situation:
   (a) Mass of $^{7}_{3}Li$ nucleus $= 7.016amu$
   (b) Mass of $^{37}_{17}Cl$ nucleus $= 6.13834818 \times 10^{-26} kg$

4. Describe the **binding energy curve** and the **iron limit**.

5. Calculate the minimum amount of energy needed to transform $^{43}_{20}Ca$ atom (of mass $42.958766u$) into $^{42}_{20}Ca$ atom (of mass $41.958618u$) through the removal of a neutron.

6. If the mass of $^{11}_{5}B$ nucleus is $11.008757u$, calculate the binding energy per nucleon.

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Radioactivity

$$\frac{dN}{dt} = -\lambda N$$

$$N|_t = N_o e^{-\lambda t}; A|_t = A_o e^{-\lambda t}$$

$$T_{\frac{1}{2}} = \frac{ln\,2}{\lambda}$$

1. Describe the following type of radioactive decay in terms of the changes to the parent nucleus as well as the type of particles emitted:
   (a) alpha
   (b) beta
   (c) gamma
2. What do we mean by $1\,becquerel$ and $1\,Curie$?
3. What is meant by **decay constant**?
4. The decay constant of an isotope $({}^{45}_{22}X)$ with mass $45g$ is $6.25 \times 10^{-5} s^{-1}$. Caculate the half life of this isotope and determine the decay rate when 30% of the original isotope has decayed.
5. $1g$ of ${}^{255}_{80}X$ has an activity of 3×10^{10}. Calculate
   (a) the decay constant
   (b) the activity of this sample after 5 years.
6. At the beginning, the number of particle of a radioactive isotope is e^4 particles. At time $t = 5minutes$, the number of particle drops to e particles. Determine the decay equation.
7. The half life of plutonium is 24000 years. If stored for 96000 years, how much of the original amount is left?