INSTITUTE OF ENGINEERING

ADVANCED COLLEGE OFENGINEERING AND MANAGEMENT

DEPARTMENT OF APPLIED SCIENCES

ENGINEERING PHYSICS

[TUTORIAL SHEETS]

BCT/BEI (I/I)

Contents

Tutorial No: 1

Oscillation

Mechanical Oscillation

1. A mass of 2 kg is suspended from a spring of spring constant 18 N/m. If the un-damped frequency is $2/\sqrt{3}$ times the damped frequency, what will be its damping factor?[$\boldsymbol{Ans; b = 6\ N.s/m}$]
2. If the relaxation time of a damped harmonic oscillator is 50 sec. Find the time in which the amplitude falls to $\frac{1}{e^3}$ times the initial value and energy of the system falls to $\frac{1}{e^4}$ of its initial value.[$\boldsymbol{Ans; t = 300\ sec. and\ t = 200\ sec.}$]
3. A wire has a torsional constant of 2 $N.m/rad$. A disc of radius $R = 5\ cm$ and mass 100g is suspended at its center. What is the frequency of torsional oscillation? **[Ans; 20.13 Hz]**
4. A 0.5 kg block is attached to a spring ($k = 12.5N/m$). The damped frequency is 0.2% lower than the natural frequency. a) What is the damping constant? b) how does the amplitude vary in time? c) What is the critical damping constant.
5. A meter stick suspended from one end swings as a physical pendulum (a) what is the period of oscillation. (b) What would be the length of the simple pendulum that would have a same time period. **[Ans:- 1.638sec, 0.666m]**

Assignment 1

Mechanical Oscillation

1. The amplitude of lightly damped oscillator decreases by 3% during each cycle. What fraction of the energy of the oscillator is lost in each full oscillation? **[Ans; 0.9409]**
2. In damped harmonic motion, calculate the time in which (i) its amplitude and (ii) its energy falls to 1/e of its un-damped value if the mass of the system is 0.25 gm and damping constant is 0.01g/s? **[Ans; 50 sec and 25 sec]**
3. A 750 gm block oscillates on the end of a spring whose force constant is 56 N/m. The mass moves in a fluid which offers a resistive force $\mathrm{F} = -\mathrm{bv}$, where $\mathrm{b} = 0.162\ \mathrm{Ns/m}$. What is the period of the oscillation? **[Ans; 0.727 sec]**
4. If the relaxation time of a damped harmonic oscillator is 50 sec. Find the time in which the amplitude falls to $\frac{1}{e}$ times the initial value and energy of the system falls to $\frac{1}{e^2}$ of its initial value.[$\boldsymbol{Ans; t = 100\ sec. and\ t = 100\ sec.}$]

Tutorial No: 2

Acoustics

1. The volume of a room is $600\ \mathrm{m}^3$, wall area of a room is $220\ \mathrm{m}^2$. The floor and ceiling area each is $120\ \mathrm{m}^2$. If average absorption coefficient for wall is 0.03 for ceiling is 0.80 and for floor is 0.06, calculate average absorption coefficient and reverberation time?**[Ans; 0.2386 and 0.864 sec]**
2. A lecture hall with a volume of $4500\ m^3$ is found to have a reverberation time of 1.5 sec. What is the total absorbing power of the entire surface in the hall? If the area of sound absorbing is $1600\ m^2$. Calculate average absorption coefficient. **[Ans; 474 and 0.296]**
3. What is the reverberation time for hall with length 12 m, breadth 11 m and height 9 m, If the coefficient of absorption of walls, ceiling and floor are $0.02, 0.04,$ and 0.08 respectively. **[Ans; 7.78 sec]**

4. The time of reverberation of an empty hall and with 500 audience is 1.5 sec and 1.4 sec respectevely. Find the reverberation time with 800 audience in the hall.**[1.346 sec]**
5. The time of reverberation of an empty hall and with 500 audience is 1.5 sec and 1.4 sec respectevely. Find the number of person in the hall if the reverberation time falls to 1.312 sec.**[Ans; 1003]**
6. A room has dimension of $6m \times 4m \times 5m$. Find (i) mean free path of sound wave in the room. And (ii) The number of reflection made per second by the sound wave. Given that velocity of sound is 350 m/sec.**[Ans; 3.342 m and108]**

Assignment 2

1. A lecture hall with a volume of 60,000 cu. Ft. is found to have a reverberation time of 1.6 sec. What is total absorbing power of the entire surface in the hall? If the area of the sound absorbing surface is 9000 sq. ft. Calculate average absorption coefficient. **[Ans; 1875]**
2. The volume of room is 960 m^3. The wall area of the room is 160 m^2, ceiling area 96 m^2 and floor area 90 m^2. The average sound absorption coefficient (i) for wall is 0.03 (ii) for ceiling is 0.80 and (iii) for the floor is 0.06. Calculate the average sound absorption coefficient and reverberation time. **[Ans; 0.2514, 1.743 sec]**
3. A lecture hall of volume $12 \times 10^4 m^3$ has a total absorption of 13200 m^2 of open window unit. Entry of students in to the hall raises the absorption by another 13200 m^2 of open window unit. Find the change in reverberation time. **[Ans; 0.718]**
4. Calculate the reverberation time of small hall of 1500 m^3 having seating capacity of 120 persons when i) The hall is empty and ii) with full capacity of the audience for the following data. **[Ans; 2.99 sec,1.795 sec]**

Surface	Areas	Coefficient of absorption
Plastered wall	112 m^2	0.03
Wooden flower	130 m^2	0.06
Plastered ceiling	170 m^2	0.04
Wooden doors	20 m^2	0.06
Cushioned chairs	120	0.5
Audience	120	0.44

Tutorial No: 3
Heat and Thermodynamics

1. A petrol engine consumes 25 liters of petrol per hour. The calorific value of petrol is $4.788 \times 10^7\ J/liter$. The output of engine is 35 KW. Calculate the efficiency of the engine. **[Ans; 10.5 %]**
2. If Einsteins temperature of a solid is 373 K, Calculate the frequency of the Einsteins oscillator. **[Ans; $\mathbf{7.8 \times 10^{12}\ HZ}$]**
3. Calculate the kinetic energy of oxygen and argon at 127° C. **[Ans; $\mathbf{8.31 \times 10^3\ J}$ and $\mathbf{4.98 \times 10^3\ J}$]**

4. If the dry air has $T_C = 132K, P_C = 37.2$ atmospheres. Calculate the Vander Waals constants. [Ans; $\boldsymbol{a = 13.51 \times 10^{-2}\ N/m^2}$ and $\boldsymbol{b = 3.65 \times 10^{-5} m^3}$]
5. Calculate the increase in boiling point of water at 100° C when the pressure is increase by one atmosphere. Latent heat of vaporization of steam is 540 cal/gm and 1 gm of steam occupies a volume of 1677cm^3. **[Ans; 27.92K]**
6. Calculate the change in entropy when 5 kg of water at 100° C is converted into steam at the same temperature. Given latent heat of steam is 540 cal/gm. **[Ans;** $\boldsymbol{3.04 \times 10^4\ J/K}$]
7. If the surface area of a human body is 1.20 m^2 and surface temperature is 27°C, i) Find the total rate of radiation on energy from the body. If the temperature of the surrounding is at 20°C, ii) What is the net rate of heat loss from the body by radiation? **[Ans; 551W, 49.6 W]**
8. If two rods of equal length and diameters having thermal conductivities 2 and 3 units respectively are joined in series, what will be the thermal conductivity of the combination? **[Ans; K = 2.4]**

Assignment 3

1. If a solid has Einsteins temperature 473 K, calculate its specific heat at 373 K. **[Ans; 21.87 J/mol.K]**
2. Find the translational kinetic energy of one mole of monoatomic gas at normal temperature and pressure. What will be its value at 273° C? **[Ans;** $\boldsymbol{3.4 \times 10^3 J\ and\ 6.8 \times 10^3 J}$]
3. Calculate the pressure required to lower the melting point of ice at 1°C, If $L = 3.36 \times 10^5 J/kg$, specific volume of water at $0°C = 10^{-3} m^3$, specific volume of ice at $0°C = 1.091 \times 10^{-3} m^3$. **[Ans;**$\boldsymbol{135.2 \times 10^5 Nm^{-2}}$**]**
4. Calculate the specific heat of saturated steam given that specific heat of water at 100°C is 1.01 and latent heat vaporization decreases with rise in temperature at the rate of 0.64 cal/ K.gm. The latent heat of vaporization of steam is 540 cal/gm. **[Ans; -1.077 cal/gm]**
5. If two rods of equal length and diameter having thermal conductivity 2 and 3 units respectively are joined in parallel, what will be the thermal conductivity of the combination? **[Ans; 2.5 units]**
6. Calculate the temperature of the sun as a perfect black body having radius $6.88 \times 10^5\ km$, the distance between the sun and earth is $1.50 \times 10^8 km$ and the solar constant $\rho = 1.33 KW/m^2$. **[Ans; 5760K]**

Tutorial No: 4

Physical optics

Interference

1. In Newton's ring experiment diameter of 15th ring was found to be 0.59 cm and that of 5th ring was 0.336 cm. If the radius of the Plano-convex lens is 100 cm. Calculate the wavelength of light used.[$\boldsymbol{Ans}$; $\boldsymbol{\lambda = 5900\ A^0}$]

2. Newton's ring formed by sodium light between a flat glass plate and a convex lens are viewed normally, what will be the order of the dark ring which will have double the diameter of 40th ring?[$\boldsymbol{Ans};\ \boldsymbol{n = 160}$]
3. In Newton's ring experiment diameter of the 10th dark ring changes from $1.4\ cm$ to $1.27\ cm$. When a liquid is introduced between the lens and the plate. Calculate refractive index of liquid.[$\boldsymbol{Ans};\ \boldsymbol{\mu = 1.215}$]
4. In Newton's ring experiment radius of the 4th and 12th ring are $0.26\ cm$ and $0.37\ cm$ respectively. Find the diameter of 24th ring. [$\boldsymbol{Ans};\ \boldsymbol{D_{24} = 0.911\ cm}$]
5. A parallel beam of sodium light of wavelength $5890\ \times 10^{-8} cm$ is incident on a thin glass plate of refractive index 1.5 such that the angle of refraction in the plate is 60^0. Calculate the smallest thickness of the plate which will make it appear dark by reflection.[$\boldsymbol{Ans}; \boldsymbol{t = 3927 \times 10^{-8}\ cm}$]
6. A glass wedge of angle 0.01 radian is illuminated by monochromatic light of 600 nm falling normally on it. At what distance from the edge of the wedge will the tenth fringe be observed by reflected light? **[**$\boldsymbol{Ans}; \boldsymbol{fringe\ width = 3 \times 10^{-4} m}$]
7. Light of Wavelength 6000 A° falls normally on a thin wedge shaped film of refractive index 1.4 forming fringes that are 2 mm apart. Find the angle of wedge. **[** ***Ans;*** $\boldsymbol{1.07 \times 10^{-4}\ rad}$]

Diffraction

8. A diffraction grating is 3 cm wide produces the second order at 33^0 with light of wavelength 600 nm. What is the total number of lines in the grating?[$\boldsymbol{Ans};\ \boldsymbol{N = 13616\ lines}$]
9. Plane diffraction grating has $5000\ lines/cm$. How many maxima can be observed, when a plane wave of wavelength $5500\ A°$ is made to incident on it.[$\boldsymbol{Ans};\ \boldsymbol{n = 4}$]
10. Calculate the possible order of spectra with a plane transmission grating having $18000\ lines/inch$. When light of wavelength is $4500\ A°$.[$\boldsymbol{Ans};\ \mathbf{n = 3}$]

Polarization

11. A $200\ mm$ long tube containing $48\ cm^3$ of sugar solution produces an optical rotation 11° when placed in saccharimeter. If the specific rotation of sugar solution is 66°. Calculate the quantity of sugar contained in the tube in the form of solution.[$\boldsymbol{Ans}; \boldsymbol{m = 4\ gm}$]
12. A sugar solution in a tube of length $20\ cm$ produces an optical rotation of 13°. The solution is then diluted to 1/3 of its previous concentration. Find the optical rotation produced by 30 cm long tube containing the diluted solution.[$\boldsymbol{Ans};\ \boldsymbol{\theta_2 = 6.5°}$]
13. Find the specific rotation of the sample of sugar solution, if the plane of polarization is turned through 46°. The length of the tube containing 20 % solution is 20 cm. [$\boldsymbol{Ans}; \boldsymbol{S = 115°}$]
14. A length of $25\ cm$ of solution containing $50\ gm$ of solute per liter causes the rotation of the plane of polarization of light by 5°. Find the rotation of plane of polarization by length of $75\ cm$ of a solution containing $100\ gm$ of solute per liter.[$\boldsymbol{Ans}; \boldsymbol{\theta_2 = 30°}$]
15. A sugar solution produces an optical rotation of 9.9° when placed in a tube of length of $20\ cm$. If the specific rotation of the solution is 66°. Find the concentration of the solution in gm/liter.[$\boldsymbol{Ans}; \boldsymbol{C = 75\ gm/l}$]
16. A beam of plane polarized light is converted into circularly polarized light by passing it through a crystal of thickness $3 \times 10^{-5}\ m$. Calculate the difference in refractive indices

of two rays inside the crystal. Wavelength of light is $600\,nm$. [$\boldsymbol{Ans}$; $(\mu_0 - \mu_e) = \mathbf{5 \times 10^{-3}}$]

17. Plane polarized light is incident on a piece of quartz cut parallel to the axis. Find the least thickness for which the ordinary and extra ordinary rays combined to form plane polarized light. (Given:- $\mu_0 = 1.5442$, $\mu_e = 1.553$ and $\lambda = 5 \times 10^{-7} m$)[$\boldsymbol{Ans}$; $\boldsymbol{t = 2.75 \times 10^{-3}\ cm}$]

Geometrical Optics

1. Two thin convex lenses having focal lengths 10 cm and 4 cm are coaxially separated by a distance 5 cm, find the equivalent focal length of the combination. Determine also the position of the principal points.[$\boldsymbol{Ans}$; $\boldsymbol{f = 4.4\ cm, \alpha = 5.5\ cm, \beta = -2.2\ cm}$]
2. Two thin lenses of focal lengths 8 cm each are identical and coaxially separated by 4 cm. Determine the equivalent focal length of this lens combination and illustrate the principal points in figure. If the image is formed at infinity at a particular position of the object, find the object distance.[$\boldsymbol{Ans}$; $\boldsymbol{f = 5.33\ cm, \alpha = 2.67\ cm, \beta = -2.67\ cm, u = -5.33\ cm}$]
3. Two thin converging lenses of focal lengths 3 cm and 4 cm are placed coaxially in air separated by distance of 2 cm. An object is placed 4 cm in front of the first lens. Find the position and nature of the images. **[Ans; Distance of the image from the second lens = 2.86 cm. The image is real.]**
4. The object glass of a telescope is an achromat of focal length 90 cm, If the magnitude of the dispersive power of the two lenses are 0.024 and 0.036, Calculate their focal lengths.[$\boldsymbol{Ans}$; $\boldsymbol{f_1 = 30\ cm}$ **and** $\boldsymbol{f_2 = -45\ cm}$]

Optical Fiber

1. An optical fiber has fractional index difference of 0.2 and cladding refractive index 1.59. Determine the acceptance angle for the fiber for water in which, have refractive index of 1.33. [$\boldsymbol{Ans}$: **Acceptance angle (i)** $= \mathbf{62^0}$]
2. A glass clad fiber is made with core glass of refractive index 1.5 and cladding is doped to give a fractional index difference of 5×10^{-4}. Determine (i) cladding index (ii) critical angle (iii) acceptance angle, and (iv) Numerical aperture.[$\boldsymbol{Ans}$: $\boldsymbol{\mu_2 = 1.49925}$, $\boldsymbol{C = 88^0}$, $\mathbf{i_{max} = 2.79^0}$, $\boldsymbol{NA = 0.0474}$]
3. The refractive index for core and cladding for a step index fiber are 1.52 & 1.41 respectively. Calculate (i) critical angle (ii) Numerical aperture, and (iii) The maximum incidence angle.[$\boldsymbol{Ans}$: $\mathbf{C = 68.068}$, $\mathbf{\Delta = 0.072}$, $\mathbf{NA = 0.576}$, $\mathbf{i_{max} = 34.591^0}$]

Assignment 4

Interference

1. White light is incident in soap film at an angle $\sin^{-1}\left(\frac{4}{5}\right)$ and the reflected light on examination by spectrometer shows dark bands. The consecutive dark bands correspond to wavelength 6.1×10^{-5} cm and 6×10^{-5} cm. if $\mu = 1.33$ for the film, calculate the thickness.[$\boldsymbol{Ans}$; $\boldsymbol{t = 1.72 \times 10^{-3} cm}$]
2. In Newton's ring experiment, the radius of curvature of lens is 5 cm and the lens diameter is 20 mm. (a) How many bright fringes are produced? Assume that $\lambda = 589$ nm (b) How many bright rings are produced if the arrangement were immersed in water ($\mu = 1.33$).[$\boldsymbol{Ans}$; $\boldsymbol{n = 3396}$, $\boldsymbol{n' = 4516}$]

3. Newton's ring formed by sodium light viewed normally. What is the order of the dark ring which will have double the diameter of 50th ring?$[\boldsymbol{Ans};\ \boldsymbol{n = 200}]$
4. A soap film $5 \times 10^{-5}\ cm$ thick is viewed at an angle of 35°to the normal. Find the wavelength of visible light which will be absent from the reflected light.$[\boldsymbol{Ans};\ \boldsymbol{\lambda_2 = 6 \times 10^{-7} m\ and\ \lambda_3 = 4 \times 10^{-7} m}]$
5. A plano-convex lens of radius 300 cm is placed on an optically flat glass plate and is illuminated by monochromatic light. The diameter of the 8th dark ring in the transmitted system is 0.72 cm. Calculate the wavelength of light used.$[\boldsymbol{Ans};\ \boldsymbol{\lambda = 5.4 \times 10^{-7} m}]$
6. Newton's rings are observed in reflected light of wavelength 5900 A°. The diameter of the 10th dark ring is 50 mm. Find the radius of curvature of lens and thickness of the air film.$[\boldsymbol{Ans};\ \boldsymbol{R = 105.932 m},\ \boldsymbol{t = 2.95 \times 10^{-6} m}]$
7. Interference fringes are produced with monochromatic light falls normally on the wedge shaped film of cellophane with refractive index of cellophane is 1.45. The angle of a wedge is 40 seconds of an arc and the distance between successive fringe is 0.125 cm. Calculate the wavelength of light? $[\boldsymbol{\lambda = 7.02 \times 10^{-7} m}]$

Diffraction

8. A diffraction grating used at normal incidence gives a line (540 nm) in a certain order superposed on the violet line (405 nm) of the next higher order. How many lines per cm are there in the grating if the angle of diffraction is 30°.$[\boldsymbol{Ans}; \boldsymbol{N = 3086\ lines/cm}]$
9. A grating with 250 groves/ mm is used with an incandescent light source. Assume visible spectrum to range in wavelength from 400 to 700 nm. In how many orders can one see the entire visible spectrum?$[\boldsymbol{Ans};\ \boldsymbol{n = 5}]$
10. In a Fraunhofer single slit diffraction, a convex length of focal length 20 cm is placed just after the slit of width 0.6 nm. If a plane wave of wavelength 6000 A° falls on slits normally, calculate the separation between the second minima on either side of central maxima.$[\boldsymbol{Ans};\ \boldsymbol{d = 3 \times 10^{-2} mm}]$
11. Light of wavelength 600 nm is incident normally on a slit of width 0.1 mm. Calculate the intensity at $\theta = 0.2^o$.$[\boldsymbol{Ans};\ \boldsymbol{I_\theta = 0.28 I_0}]$
12. A screen containing two slits 0.1 mm apart is 1m from the viewing screen. Light of wavelength 500 nm falls on the slits from a distant source. Approximately how far apart will the bright interference fringes be seen on the screen?$[\boldsymbol{Ans};\ \boldsymbol{\beta = 5\ mm}]$

Polarization

13. A plane polarized light is incident perpendicularly on a quartz plate cut with faces parallel to optic axis. Find the thickness of quartz plate, which introduces phase difference of 60°between e-rays and o-rays. $[\boldsymbol{Ans}: \boldsymbol{10\ \mu m}]$
14. A 30 cm long polarimeter tube containing 50 cm³ of sugar solution produces an optical rotation 14.5° when placed on a polarimeter tube. If the specific rotation of the sugar solution is 65°, calculate the quantity of sugar contained in the tube.$[\boldsymbol{Ans}: \boldsymbol{3.60\ gm}]$
15. Calculate the thickness of double refracting plate capable of producing a path differences of λ/4 between extraordinary and ordinary rays of wavelength 5890 A°. (Use $\mu_0 = 1.53$ and $\mu_e = 1.54$)$[\boldsymbol{Ans}: \boldsymbol{1.47 \times 10^{-3} cm}]$
16. If the plane of vibration of the incident beam makes an angle of 30° with the optic axis, compare the intensities of extraordinary and ordinary light. $[\boldsymbol{Ans}: \boldsymbol{\frac{I_E}{I_O} = 3:1}]$

17. A beam of polarized light is sent in to a system of two polarizing sheets. Relative to a polarization direction of the incident light. The polarizing directions of the sheets are at angle θ for the first sheet and 90° for the second sheets. If the 0.1 of the incident intensity is transmitted by the two sheets, what is θ?[$\boldsymbol{Ans}$: $\boldsymbol{\theta = 19.6° \ and \ 70.4°}$]

Geometrical Optics

1. Two thin converging lenses of focal lengths 30 cm and 40 cm respectively are placed co-axially in air separated by a distance of 20 cm. An object is placed 40 cm in front of the first lens. Find the position and nature of the image and its lateral magnification. [$\boldsymbol{Ans: v = 44.6 \ cm \ and \ M = 0.86}$]

2. Two thin identical convexes lenses of focal length 8cm and each are placed co-axially 4cm apart. Find the principal points and the position of object for which image is formed at infinity. [$\boldsymbol{Ans: \alpha = 2.66 \ cm, \beta = \ -2.66 \ cm \ and \ \ 2.67cm}$]

3. A convex lens of 10 cm focal length is placed in air from a concave lens of focal length 20 cm, at a distance of 5 cm. Find the distance between the two principal points of the combination. [$\boldsymbol{Ans: \alpha = -3.32 \ cm, \ \beta = \ -6.65 \ cm}$**and the distance between the two principal points** $=$ $\boldsymbol{1.67 \ cm}$]

4. Two lenses of focal lengths 8 cm and 4 cm are placed at a certain distance apart. Calculate the position of principal points if they form an achromatic combination.[$\boldsymbol{Ans: \ \alpha = 8 \ cm \ and \ \beta = \ -4 \ cm}$]

5. Two thin converging lenses of focal lengths 0.2 m and 0.3 m are placed co-axially 0.10 m apart in air. An object is located 0.6 m in front of the lens of smaller focal length. Find the position of two principal points and that of image.[$\boldsymbol{Ans: \alpha = 0.05 \ m, \beta = -0.075 \ m \ and \ v = 1.95 \ m}$]

Optical Fiber

1. An optical fiber has a numerical aperture of 0.22 and core refractive index 1.62. Determine the acceptance angle for the fiber in liquid which has a refractive index of 1.25. Also, determine the refractive index change.[$\boldsymbol{Ans: \ 0.0092}$]

2. Calculate the refractive index of the core and materials of a fiber from following data. Numerical Aperture (NA) = 0.22 and fractional refractive index change $\Delta =$ 0.012. [$\boldsymbol{Ans: \ \mu_1 = 1.42 \ and \ \ \mu_2 = 1.403}$]

Tutorial No: 5

Electrostatics and Capacitor

1. A spherical drop of water carrying a charge of 30 PC has potential of 500 volts at its surface. (i) What is the radius of the drop? (ii) If two drops of same charge and radius combined to form a single spherical drop, what is the potential at the surface of new drop?[**Ans**; $\mathbf{r = 5.4 \times 10^{-4} \ m, \ \ V = 794.12 \ Volts}$]

2. Two small spheres of charge 10 μC and 40 μC are placed 5 cm apart. Find the location of a point between them where field strength is zero.[$\boldsymbol{Ans; \ x = 1.67 \ cm}$**]**

3. Assume that earth have surface charge density of 1.6×10^{-10} $electron/m^2$. Calculate earth's electric field and potential on the earth surface. Given that radius of earth is 6400 km. [**Ans**; $\mathbf{E = 18.08 \ V/m, V = 1.157 \times 10^8 \ Volts}$]

4. A charge of 5×10^{-5} C is distributed between two sphere. It is found that they repeal each other with a force of 1 N. when their centers are 2 m apart find the charge on each sphere.[$\boldsymbol{Ans; \ q_1 = 3.84 \ \times 10^{-5} \ C, \ q_2 = 1.15 \times 10^{-5} C}$]

5. The electric potential V varies with x according to the relation $V = 5 + 4x^2$. Calculate the force experience by a negative charge of $2 \times 10^{-6}\ C$ located at $x = 0.5\ m$.[$\boldsymbol{Ans;\ F = 8 \times 10^{-6}\ N}$]
6. An air filled parallel plate capacitor has a capacitance of $10^{-12} F$. The separation between the plate is double and wax is inserted between them which increases the capacitance to $2 \times 10^{-1}\ F$. Calculate the dielectric constant of wax.[$\boldsymbol{Ans;\ k = 4}$]
7. A parallel plate capacitor has capacitance of $100\ \mu\mu F$. A plate area of $100\ cm^2$ and mica as dielectric material, with $50\ V$ potential difference. Calculate (i) Electric field in mica. (ii) The free charge on the plates and (iii) The induced surface charge (q^I). Given k = 5.4 for mica. [$\boldsymbol{Ans; E = 1.05 \times 10^4 \frac{V}{m},\ q = 5 \times 10^{-9}\ C,\ q' = 4.1 \times 10^{-9}\ C}$]
8. A capacitor of capacitance C is discharge through a resistor of resistance R. After how many time constant is the stored energy becomes 1/4th of initial value?[$\boldsymbol{Ans;\ t = 0.693\ \tau}$]
9. A capacitor of capacitance C is charged through a resistor R. Calculate the time at which potential across the resistor is equal to the potential across the capacitor. [$\boldsymbol{Ans;\ t = 0.693\ RC}$]
10. If n drops each of capacitance C combine to form a single big drop. Find the capacitance of big drop.$\left[\boldsymbol{Ans; C_b = C.n^{\frac{1}{3}}}\right]$
11. A parallel plate capacitor has circular plate of 8.2 cm radius and 1.3 mm separation in air. (i) Calculate the capacitance and (ii) What charge will appear on the plates, if potential difference of 120 V is applied.[$\mathbf{Ans;\ C = 1.497 \times 10^{-10}\ F,\ q = 1.725 \times 10^{-8}\ C}$]

Assignment 5

1. Two equal and opposite charge of magnitude 2×10^{-7} C are 15 cm apart (i) what are the magnitude and direction of E at a point mid way between the charges? (ii) What force would act on an electron placed there? [$\boldsymbol{Ans; 6.4 \times 10^5 N/C,\ 1.024 \times 10^{-13} N}$]
2. The electric potential V due to a charge in the surrounding space at any point x meters from the charge is given by the relation, $V = 8x + 3x^2$ volts. Find the electric field intensity at a point 1.5 m from the charge. Consider the medium is air. [$\boldsymbol{Ans;\ 17.6\ N/C}$]
3. A parallel plate capacitor whose capacitance C is 13.5 pF is charged by a battery to a potential difference V = 12.5 V between its plates. The charging battery disconnected and a porcelain slab (k = 6.50) is supplied between the plates. (a) What is the potential energy of the capacitor before the slab is inserted (b) what is the potential energy of the capacitor-slab device after the slab is inserted?[$\boldsymbol{Ans; 1.05 \times 10^{-9}\ J,\ 1.62 \times 10^{-10}\ J}$]
4. The parallel plates in a capacitor, with a plate area 8.5 cm^2 and air filled separation of 3 mm are charged by 6 V batteries. They are then disconnected from the battery and pulled apart to a separation of 8 mm. Neglecting fringing; find (a) the potential difference between the plates (b) the initial energy stored and (c) final energy stored.[$\boldsymbol{Ans; 16\ V, 4.51 \times 10^{-11} J,\ 1.20 \times 10^{-10}\ J}$]
5. A spherical drop of water carrying a charge of 30 pC has a potential of 500 V at its surface. (a) What is the radius of the drop? (b) If two such drops of the same charge and radius combine to form a single spherical drop, what is the potential at the surface of the new drop?[$\boldsymbol{Ans;\ 5.4 \times 10^{-4}\ m,\ 793.7\ V}$]

6. What is the force per unit area with which plates of parallel plate capacitor attract each other if they are separated by 1 mm and maintain at 100 V potential difference and electric constant of the medium in unity.[$\boldsymbol{Ans}$; $\mathbf{5 \times 10^9}$ $\boldsymbol{N/m^2}$]
7. A parallel plate capacitor each of area 100 cm^2 has a potential difference of 500 V and capacitance of 100 $\times 10^{-6}$ μF. If a mica of dielectric constant 5.4 is inserted between plates find the magnitude of (a) Electric field in mica (b) Displacement vector and(c) Polarization vector.[$\boldsymbol{Ans}$; $\mathbf{1.04 \times 10^5}$ $\boldsymbol{Vm^{-1}}$, $\mathbf{5 \times 10^{-6}}\boldsymbol{Cm^{-2}}$, $\mathbf{4.07 \times 10^{-6}}\boldsymbol{Cm^{-2}}$]

Tutorial No: 6

Electromagnetic Induction

1. An inductor of self inductance100 mH, and resistor of resistance 50 Ω are connected to a 2 V battery. Calculate the time required for the current to fall to half of its steady state value.[$\boldsymbol{Ans}$; $\boldsymbol{t} = \mathbf{1.38 \times 10^{-3}}\boldsymbol{sec}$]
2. A solenoid of inductance L and resistor R is connected to a battery. After how many time constant the magnetic energy fall to 1/4th of its maximum value?[$\boldsymbol{Ans}$; $\mathbf{t = 0.693\ \tau\ Sec}$]
3. A 45 V of potential difference is suddenly applied to a coil with $L = 50\ mH$ and $R = 180\ \Omega$. At what rate is the current increasing after 1.2 mili second. $\left[\boldsymbol{Ans}; \therefore \frac{dI}{dt} = \mathbf{11.97}\ \boldsymbol{A/sec}\right]$
4. An ideal inductor of self inductance5 H and a resistance of 100 Ω is suddenly connected in series to a battery of 6 V. Calculate (i) The steady current in the circuit. (ii) The maximum rate of increase of current. (iii) The time constant.[**Ans**; $\mathbf{0.06\ A}$, $\mathbf{1.2}\ \boldsymbol{A/}$ $\mathbf{sec}$ $\boldsymbol{and}$ $\mathbf{0.05\ sec}$]
5. A Circular loop of wire 5 cm in radius carries a current of 5 A. What is the energy density at the centre of the loop?[$\boldsymbol{Ans}$; $\mathbf{1.58 \times 10^{-3}}$ $\boldsymbol{joule/m^3}$]
6. What is the magnetic energy density at the centre of a circulating electron in the hydrogen atom. Assume that the electron circulate around the nucleus in a path of radius 5.1×10^{-11} $metre$ at a frequency of 6.8×10^{15} $revs/sec$.[$\boldsymbol{Ans}$; $\mathbf{7.15 \times 10^7}$ $\boldsymbol{J/m^3}$]
7. Flux ϕ (in weber) in a closed circuit of resistance 10 Ω varies with time t (in second) According to the equation $\emptyset = 6t^2 - 5t + 2$. Calculate the magnitude of induced current in the circuit at t = 0.25 sec. [$\boldsymbol{Ans}$; $\mathbf{0.2}\ \boldsymbol{A}$]

Assignment 6

Electromagnetic Induction

1. A toroid has number of turns 1250, internal radius 52 mm, external radius 95 mm and thickness of the ring 13mm calculate the inductance.[$\boldsymbol{Ans}$; $\mathbf{2.448 \times 10^{-3}}\boldsymbol{H}$]
2. A solenoid having an inductance of 6.3 μH is connected in series with a 1.2 kΩ resistance. (a) If a 14 V battery is connected across the pair, how long it will take for the current through the resistor to reach 80 % of its initial value? (b) What is the current through the resistor at time $t = \tau_L$.[$\boldsymbol{Ans}$; $\mathbf{8.45 \times 10^{-9}}\boldsymbol{sec}$, $\mathbf{7.37 \times 10^{-3}}\boldsymbol{A}$]
3. An inductance L is connected to a battery of emf E through a resistance. Show that the potential difference across the inductance after time t is $V_L = \varepsilon\, e^{\frac{-Rt}{L}}$. At what time is the potential difference across the inductance equal to that across the resistance such that $i = \frac{i_0}{2}$.[$\boldsymbol{Ans}$; $\mathbf{0.693}\ \boldsymbol{L/R}$]

4. A solenoid is 1.3 m long and 2.6 cm in diameter carries a current of 18 A. The magnetic field inside the solenoid is 23 mT. Find the length of the wire forming the solenoid. Also calculate the inductance of solenoid.$[\boldsymbol{Ans};\ \mathbf{108}\boldsymbol{m}, \mathbf{8.967} \times \mathbf{10^{-4}}\boldsymbol{H}]$
5. What must be the magnitude of a uniform electric field have the same energy density that passed by a 0.50 T magnetic field? $[\boldsymbol{Ans}; \mathbf{1.5} \times \mathbf{10^{8}}\ \boldsymbol{V/m}]$
6. Deuterons in a cyclotron describe a circle of radius 0.32 m just before emerging from Dees. The frequency of the applied emf is 10 MHz. Find the flux density of the magnetic field and energy of the deuterons emerging out of the cyclotron. (mass of deuterons = 3.32×10^{-2} kg.) $[\mathbf{Ans};\ \mathbf{1.303T}, \mathbf{6.702} \times \mathbf{10^{-13}}\boldsymbol{J}]$

Tutorial No: 7

Electromagnetic waves

1. Calculate the magnitude of the Poynting vector and the amplitude of the electric and magnetic fields at a distance of 10 cm from a radio station which is radiating power of 10^5 watt uniformly over a hemisphere with radio station as center.$[\boldsymbol{Ans};\ \mathbf{E_0} = \mathbf{3.5} \times \mathbf{10^4\ V/m}, \mathbf{B_0} = \mathbf{120\ \mu T\ and}\ \boldsymbol{S} = \mathbf{3.34}\ \times \mathbf{10^6\ W/m^2}]$
2. Using the Pyonting vector calculate the maximum electric and magnetic fields for sun-light if the solar constant is 1.4 KW/m^2.$[\mathbf{Ans};\ \mathbf{B_0} = \mathbf{3.4\ \mu T\ and\ E_0} = \mathbf{1020}\ \boldsymbol{V/m}]$
3. Calculate the displacement current between the square plates of capacitor having one side 1 cm if the electric field between the plate is changing at the rate of 3×10^6 V/meter-sec.$[\mathbf{Ans};\ \mathbf{I_d} = \mathbf{2.655} \times \mathbf{10^{-9}\ A}]$
4. A parallel plate capacitor has capacitance 20 µF. At what rate the potential difference between the plates must be changed to produce a displacement current of 1.5 A?$[\mathbf{Ans};\ \frac{\mathbf{dV}}{\mathbf{dt}} = \mathbf{7.4} \times \mathbf{10^4\ Volts/sec}]$
5. An observer is 1.8 m from an isotropic point light source whose power is 250 watt. Calculate the *rms* values of the electric and magnetic fields due to the source at the position of observer.$[\boldsymbol{Ans};\ \boldsymbol{E_{rms}} = \mathbf{48.11}\boldsymbol{V/m\ andB_{rms}} = \mathbf{1.61} \times \mathbf{10^{-7}}\ \boldsymbol{T}]$
6. A parallel plate capacitor with circular plates of 10 cm radius is charged producing uniform displacement current of magnitude 20 A/m^2.Calculate (i) Calculate the curl of magnetic flux density between the plates (ii) Calculate the rate of change of electric field in this region.$[\boldsymbol{Ans};\ \nabla \times \vec{\boldsymbol{B}} = \mathbf{2.512} \times \mathbf{10^{-5}}\ \boldsymbol{Wb/m^2\ and\ I_d} = \mathbf{2.26} \times \mathbf{10^{12}\ V/ms}]$

Assignment 7

1. The maximum electric field 10 m from an isotropic point source of light is 2 V/m. What are (a) the maximum value of the magnetic field and (b) the average intensity of light there? (c) What is the power of the source?$[\boldsymbol{Ans};\ \mathbf{6.67} \times \mathbf{10^{-9}}\boldsymbol{T}, \mathbf{5.305} \times \mathbf{10^{-3}}\boldsymbol{Wm^{-2}}, \mathbf{6.7}\boldsymbol{W}]$
2. A certain plane electromagnetic wave emitted by a microwave antenna has a wavelength of 3 cm and a maximum magnitude of electric field of $2 \times 10^{-4} V/cm$. i) What is frequency ii) What is the maximum magnetic field and iii) What is the Poynting vector? $[\boldsymbol{Ans};\ \mathbf{10^{10}}\boldsymbol{Hz}, \mathbf{6.67} \times \mathbf{10^{-11}}\boldsymbol{T}, \mathbf{1.061} \times \mathbf{10^{-6}}\boldsymbol{Wm^{-2}}]$
3. The sun delivers about 10^3 W/m^2 of energy of the earth's surface through EM radiation calculate a) The total power incident on a roof of dimension 8m × 20m, b) radiation pressure and force exerted on the roof , assuming roof is perfect absorber.$[\boldsymbol{Ans};\ \mathbf{160}\ \boldsymbol{Kw}, \mathbf{3.33} \times \mathbf{10^{-6}}\boldsymbol{Nm^{-2}}, \mathbf{5.33} \times \mathbf{10^{-4}}\boldsymbol{N}]$

4. A radio wave transmits 25 W/ m^2 of power per unit area. The flat surface area is perpendicular to the direction of propagation of wave. Calculate the radiation pressure on it and maximum electric and magnetic field associated with the wave.[$\boldsymbol{Ans;\ 8.33 \times 10^{-8} Nm^{-2}, 137.293 Vm^{-1}, 4.576 \times 10^{-7} T}$]

5. A parallel plate capacitor with circular plates of 20 cm radius is charged producing uniform displacement current of magnitude 20 A/m^2.Calculate (i) dE/dt in the region (ii) displacement current density and (iii) Induced magnetic field.[$\boldsymbol{Ans;\ 2.26 \times 10^{12} Vs^{-1}, 2.5A, 2.5 \times 10^{-6} T}$]

6. Calculate the displacement current between the capacitor plates of area $1.5 \times 10^{-2} \mathrm{m}^2$ and rate of electric field change is 1.5×10^{-12} V/ms. Also calculate displacement current density.[$\boldsymbol{Ans;\ 2 \times 10^{-25} A, 1.325 \times 10^{-23} Am^{-2}}$]

Tutorial No: 8

Photon and Matter Waves

1. Calculate the wavelength associated with an electron subjected to a potential difference of 1.25 KV. [$\boldsymbol{Ans;\ 0.347\ A^0}$]
2. Find the energy of the neutron in units of eV. Which de-Broglie wavelength is 1 A^0. Given mass of neutron = $1.67 \times 10^{-27}\ Kg$. [$\boldsymbol{Ans;\ 8.13 \times 10^{-2}\ eV}$]
3. What voltage must be applied to an electron microscope to produce electron of wavelength 0.50 A^0.[$\boldsymbol{Ans;\ 597.89}$ **volts**]
4. An electron is confined to an infinite height box of size 0.1 nm. Calculate the ground state energy of the electron. How this electron can be put to the third energy level?[$\boldsymbol{Ans;\ E_1 = 38.15\ eV,\ \ E_3 = 343.35\ eV\ and\ E_3 - E_1 = 305.5\ eV}$]
5. The wave function of a particle confined in a box of length l is $\psi(x) = \sqrt{\frac{2}{l}}\ sin\frac{\pi x}{l}$. Calculate the probability of finding the particle in length 0 to $\frac{l}{2}$. [$\boldsymbol{Ans;\ 50}$ **%**]
6. Calculate the probability of transmission of α particle through the rectangular barrier indicated below. Height of the barrier $(V) = 2\ eV$, energy of α particle $(E) = 1\ eV$ barrier width $(L) = 1\ A^0$, mass of α particle $(m) =\ 6.4 \times 10^{-27}\ kg$. [$\boldsymbol{Ans;\ 2.18 \times 10^{-37}}$]

Assignment 8

1. A beam of electrons having energy of each 3eV is incident on a potential barrier of height 4eV. If the width of the barrier is 20A^0, calculate the transmission coefficient of the beam through the barrier.[$\boldsymbol{Ans;\ T = 3.87 \times 10^{-9}}$]
2. A non relativistic particle is moving three times as fast as an electron. The ratio of the de-Broglie wavelength of the particle to that of the electron is 1.813×10^{-4}. Calculate the mass of the particle.[$\boldsymbol{Ans;\ m_p = 1.67 \times 10^{-27} Kg}$]
3. Using the uncertainty principle, calculate the minimum uncertainty in velocity when an electron is confined to a length $\Delta x = 1nm$. Given, $\mathrm{m} = 9.1 \times 10^{-3}$ Kg, $\mathrm{h} = 6.6 \times 10^{-34}$ Js.(Formula:- $\Delta x \Delta p \geq \frac{h}{4\pi}$, where Δx is uncertainty in position and Δp is uncertainty of momentum). [$\boldsymbol{Ans; \Delta v = 57715.53 m/sec}$]

4. An electron is confined in an one dimensional infinite potential well of width a, the potential energy is $\mathrm{V} = 0$ for $0 \leq \mathrm{x} \leq a$and $\mathrm{V} = \infty$ for $\mathrm{x} \leq 0$ and $\mathrm{x} \geq a$. Find the Eigen functions $\psi_{\mathrm{n}}(\mathrm{x}) = \mathrm{A} \sin\left(\frac{\mathrm{n}\pi\mathrm{x}}{a}\right)$and energy Eigen values $\mathrm{E}_{\mathrm{n}} = \frac{\mathrm{n}^2\pi^2\hbar^2}{2\mathrm{m}a^2}$.
5. Calculate the permitted energy levels of an electron in one dimensional potential well of width 0.2 nm.[$\boldsymbol{Ans}$; $\boldsymbol{E_n = 1.5 \times 10^{-18} n^2 J}$]