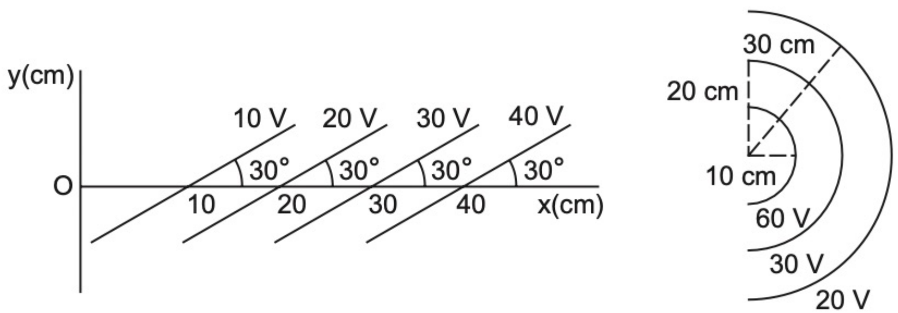
7C Spring 2023 - Review problems

E & M

64. An electric field of magnitude $1000\ \mathrm{N\,C^{-1}}$ is produced between two parallel plates having a separation of 2·0 cm as shown in figure (29-E4). (a) What is the potential difference between the plates? (b) With what minimum speed should an electron be projected from the lower plate in the direction of the field so that it may reach the upper plate? (c) Suppose the electron is projected from the lower plate with the speed calculated in part (b). The direction of projection makes an angle of 60° with the field. Find the maximum height reached by the electron.

Figure 29-E4

62. Some equipotential surfaces are shown in figure (29-E3). What can you say about the magnitude and the direction of the electric field?



(a) (b)

27. Two particles A and B having charges q and $2q$ respectively are placed on a smooth table with a separation d. A third particle C is to be clamped on the table in such a way that the particles A and B remain at rest on the table under electrical forces. What should be the charge on C and where should it be clamped?

66. How much work has to be done in assembling three charged particles at the vertices of an equilateral triangle as shown in figure (29-E5)?

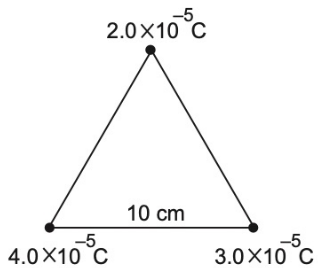
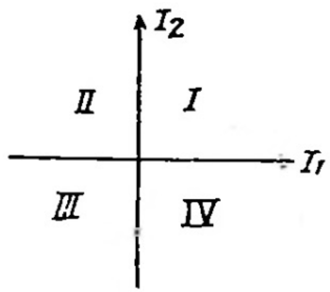
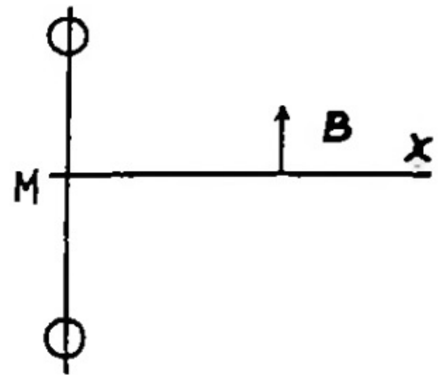


Figure 29-E5

Two mutually perpendicular conductors carrying currents i_1 and i_2 lie in (x, y) plane. Find the locus of points at which the magnetic induction is zero.



Two infinitely long parallel conductors carrying currents are directed at right angles to the drawing. The magnetic induction at a point M that lies in the middle between the conductors is zero. To the right of this point, the magnetic induction vector points upward, at right angles to the x-axis. Find the direction of the current flowing in the conductors, the direction of the magnetic induction vector to the left of point M, the relationship between the currents, and the point on the x-axis at which the magnetic induction is maximum. The distance between the conductors is a.



7. *A particle of mass* $m = 1{\cdot}6 \times 10^{-27}$ kg *and charge* $q = 1{\cdot}6 \times 10^{-19}$ C *moves at a speed of* $1{\cdot}0 \times 10^{7}$ m s^{-1}. *It enters a region of uniform magnetic field at a point E, as shown in figure (34-W4). The field has a strength of* $1{\cdot}0$ T. *(a) The magnetic field is directed into the plane of the paper. The particle leaves the region of the field at the point F. Find the distance EF and the angle* θ. *(b) If the field is coming out of the paper, find the time spent by the particle in the region of the magnetic field after entering it at E.*

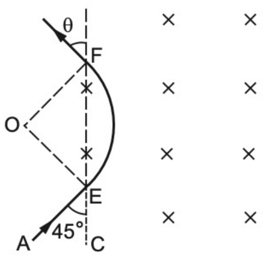


Figure 34-W4

8. *A beam of protons with a velocity of* 4×10^{5} m s^{-1} *enters a uniform magnetic field of* $0{\cdot}3$ T. *The velocity makes an angle of* $60°$ *with the magnetic field. Find the radius of the helical path taken by the proton beam and the pitch of the helix.*

43. Figure (34-E17) shows a convex lens of focal length 12 cm lying in a uniform magnetic field B of magnitude $1{\cdot}2$ T parallel to its principal axis. A particle having a charge $2{\cdot}0 \times 10^{-3}$ C and mass $2{\cdot}0 \times 10^{-5}$ kg is projected perpendicular to the plane of the diagram with a speed of $4{\cdot}8$ m s^{-1}. The particle moves along a circle with its centre on the principal axis at a distance of 18 cm from the lens. Show that the image of the particle goes along a circle and find the radius of that circle.

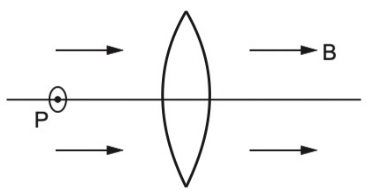


Figure 34-E17

38. A particle of mass m and positive charge q, moving with a uniform velocity v, enters a magnetic field B as shown in figure (34-E13). (a) Find the radius of the circular arc it describes in the magnetic field. (b) Find the angle subtended by the arc at the centre. (c) How long does the particle stay inside the magnetic field ? (d) Solve the three parts of the above problem if the charge q on the particle is negative.

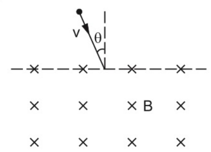
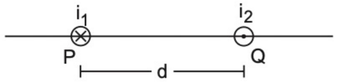


Figure 34-E13

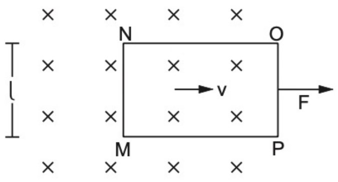
2. *Two parallel wires P and Q placed at a separation $d = 6$ cm carry electric currents $i_1 = 5$ A and $i_2 = 2$ A in opposite directions as shown in figure (35-W2a). Find the point on the line PQ where the resultant magnetic field is zero.*



(a)

Figure 35-W2

Figure (38.6a) shows a rectangular loop MNOP being pulled out of a magnetic field with a uniform velocity v by applying an external force F. The length MN is equal to l and the total resistance of the loop is R. Find (a) the current in the loop, (b) the magnetic force on the loop, (c) the external force F needed to maintain the velocity, (d) the power delivered by the external force and (e) the thermal power developed in the loop.



(a)

Figure 38.6

8. A rod AB moves with a uniform velocity v in a uniform magnetic field as shown in figure (38-Q7).
(a) The rod becomes electrically charged.
(b) The end A becomes positively charged.
(c) The end B becomes positively charged.
(d) The rod becomes hot because of Joule heating.

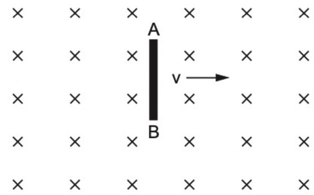


Figure 38-Q7

5. *The magnetic field B shown in figure (38-W2) is directed into the plane of the paper. ACDA is a semicircular conducting loop of radius r with the centre at O. The loop is now made to rotate clockwise with a constant angular velocity ω about an axis passing through O and perpendicular to the plane of the paper. The resistance of the loop is R. Obtain an expression for the magnitude of the induced current in the loop. Plot a graph between the induced current i and ωt, for two periods of rotation.*

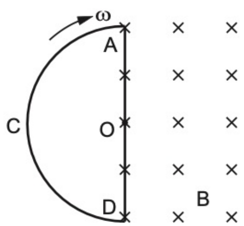


Figure 38-W2

3. Consider the situation shown in figure (38-Q2). If the switch is closed and after some time it is opened again, the closed loop will show
(a) an anticlockwise current-pulse
(b) a clockwise current-pulse
(c) an anticlockwise current-pulse and then a clockwise current-pulse
(d) a clockwise current-pulse and then an anticlockwise current-pulse.

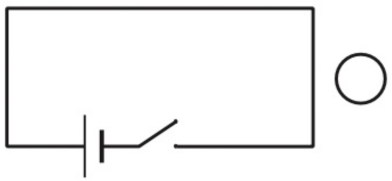


Figure 38-Q2

Quantum

8. *Monochromatic radiation of wavelength* λ *is incident on a hydrogen sample in ground state. Hydrogen atoms absorb a fraction of light and subsequently emit radiation of six different wavelengths. Find the value of* λ.

11. *(a) Find the maximum wavelength* λ_0 *of light which can ionize a hydrogen atom in its ground state. (b) Light of wavelength* λ_0 *is incident on a hydrogen atom which is in its first excited state. Find the kinetic energy of the electron coming out.*

15. *Find the wavelengths in a hydrogen spectrum between the range* 500 nm to 700 nm.

Waves

Standing waves

1. You are walking along a seashore and a mild wind is blowing. Is the motion of air a wave motion ?

2. The radio and TV programmes, telecast at the studio, reach our antenna by wave motion. Is it a mechanical wave or nonmechanical ?

1. When you speak to your friend, which of the following parameters have a unique value in the sound produced ?
(a) Frequency (b) Wavelength
(c) Amplitude (d) Wave velocity

15. The change in frequency due to Doppler effect does not depend on
(a) the speed of the source
(b) the speed of the observer
(c) the frequency of the source
(d) separation between the source and the observer.

8. *A guitar string is* 90 cm *long and has a fundamental frequency of* 124 Hz. *Where should it be pressed to produce a fundamental frequency of* 186 Hz ?

8. A standing wave is produced on a string clamped at on end and free at the other. The length of the string
(a) must be an integral multiple of $\lambda/4$
(b) must be an integral multiple of $\lambda/2$
(c) must be an integral multiple of λ
(d) may be an integral multiple of $\lambda/2$.

44. A particular guitar wire is 30·0 cm long and vibrates at a frequency of 196 Hz when no finger is placed on it. The next higher notes on the scale are 220 Hz, 247 Hz, 262 Hz and 294 Hz. How far from the end of the string must the finger be placed to play these notes ?

Doppler

22. *The driver of a car approaching a vertical wall notices that the frequency of his car's horn changes from* 440 Hz *to* 480 Hz *when it gets reflected from the wall. Find the speed of the car if that of the sound is* 330 m s^{-1}.

72. A small source of sound vibrating at frequency 500 Hz is rotated in a circle of radius $100/\pi$ cm at a constant angular speed of 5·0 revolutions per second. A listener situates himself in the plane of the circle. Find the minimum and the maximum frequency of the sound observed. Speed of sound in air = 332 m s^{-1}.

16. A small source of sound moves on a circle as shown in figure (16-Q1) and an observer is sitting at *O*. Let ν_1, ν_2, ν_3 be the frequencies heard when the source is at *A*, *B* and *C* respectively.

(a) $\nu_1 > \nu_2 > \nu_3$

(b) $\nu_1 = \nu_2 > \nu_3$

(c) $\nu_2 > \nu_3 > \nu_1$

(d) $\nu_1 > \nu_3 > \nu_2$

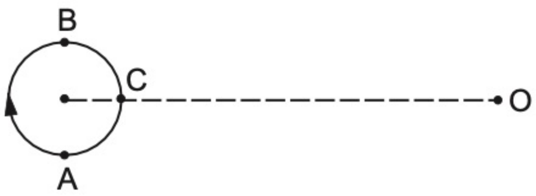


Figure 16-Q1

Interference

8. When two waves with same frequency and constant phase difference interfere,
(a) there is a gain of energy
(b) there is a loss of energy

(c) the energy is redistributed and the distribution changes with time
(d) the energy is redistributed and the distribution remains constant in time.

31. Two speakers S_1 and S_2, driven by the same amplifier, are placed at $y = 1{\cdot}0$ m and $y = -1{\cdot}0$ m (figure 16-E4). The speakers vibrate in phase at 600 Hz. A man stands at a point on the X-axis at a very large distance from the origin and starts moving parallel to the Y-axis. The speed of sound in air is 330 m s^{-1}. (a) At what angle θ will the intensity of sound drop to a minimum for the first time? (b) At what angle will he hear a maximum of sound intensity for the first time? (c) If he continues to walk along the line, how many more maxima can he hear?

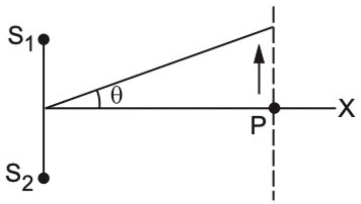
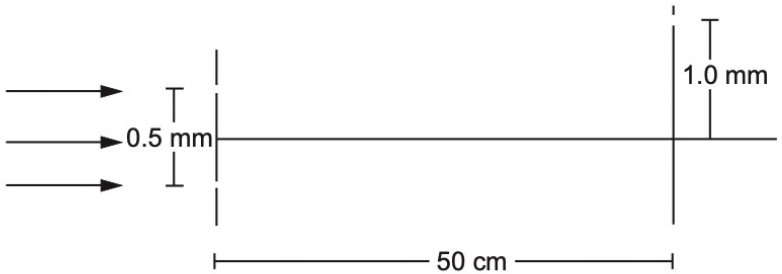


Figure 16-E4

25. White coherent light (400 nm–700 nm) is sent through the slits of a Young's double slit experiment (figure 17-E3). The separation between the slits is 0·5 mm and the screen is 50 cm away from the slits. There is a hole in the screen at a point 1·0 mm away (along the width of the fringes) from the central line. (a) Which wavelength(s) will be absent in the light coming from the hole? (b) which wavelength(s) will have a strong intensity?



Optics

2. A point source S is placed midway between two converging mirrors having equal focal length f as shown in figure (18-E3). Find the values of d for which only one image is formed.

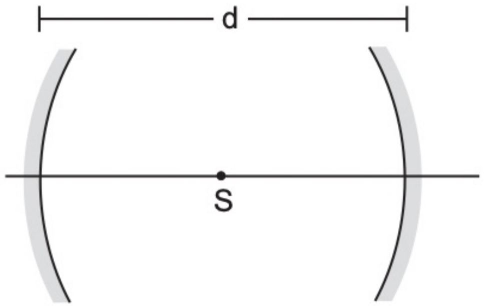


Figure 18-E3

27. A light ray is incident normally on the face AB of a right-angled prism ABC ($\mu = 1{\cdot}50$) as shown in figure (18-E9). What is the largest angle ϕ for which the light ray is totally reflected at the surface AC ?

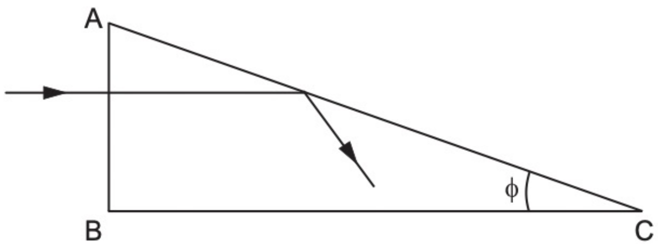


Figure 18-E9

Optometry

9. *The near and far points of a person are at* 40 cm *and* 250 cm *respectively. Find the power of the lens he/she should use while reading at* 25 cm. *With this lens on the eye, what maximum distance is clearly visible?*

10. *A young boy can adjust the power of his eye-lens between* 50 D *and* 60 D. *His far point is infinity. (a) What is the distance of his retina from the eye-lens? (b) What is his near point?*