P-II (1+1+1) H / 17 (N)

2017

PHYSICS (Honours)

Paper Code : IV-A

[New Syllabus]

Full Marks : 15 Time : Thirty Minutes

Important Instructions for OMR Sheet

1. Write / Fill your correct Subject Name, Subject Code & Paper Code in the space provided on the top of the OMR sheet (Subject Codes are given on the back of the OMR sheet & Paper Code in the Question Paper.)
2. Write / Fill your Roll number, Registration number, Regn. Session, Exam Date and Exam Session in the space provided on the OMR Sheet.
3. Each item has four alternative responses marked (A), (B), (C) and (D). You have to darken the circle as indicated below on the correct response against each item.
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6. You have to return the OMR Sheet to the invigilators at the end of the examination compulsorily and must not carry it with you outside the Examination Hall.
7. **Use only Blue/Black Ball point pen. Use of any mobile phone, calculator or log table etc. in examination hall, is prohibited.**

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Answer *all* the questions in OMR sheet.

Choose the correct answer.

Each question carries $1\frac{1}{2}$ marks.

1. The distance between two points in a medium is 4.0 m, while the corresponding optical path is 6.0 m. If the speed of light in vacuum is $3\times10^8\ ms^{-1}$, the speed in the said medium is —

   (A) $4.5\times10^8 ms^{-1}$

   (B) $3\times10^8 ms^{-1}$

   (C) $2\times10^8 ms^{-1}$

   (D) $1.5\times10^8 ms^{-1}$

2. In an achromatic doublet (which behaves as a converging lens), one of the component lenses has a focal length of +10.0 cm. The nature and focal length (f) of the other lens must be —

   (A) concave and $|f| < 10.0$ cm

   (B) concave and $|f| > 10.0$ cm

   (C) concave and $|f| = 10.0$ cm

   (D) concave and $|f| < 5.0$ cm

3. What will happen if the acute angles of a biprism are increased ?

   (A) The fringe-width will become very small.

   (B) Dark and bright fringes will superpose so that a general illumination will be obtained.

   (C) The fringes will become sharper and wider.

   (D) No noticeable effect will be found.

Turn Over

4. A plane diffraction grating has 104 lines per mm. Monochromatic light of wavelength 589 nm is incident normally on the grating. How many orders of principal maxima would be visible ?
   (A) 15
   (B) 17
   (C) 16.4
   (D) 16

5. Visible light ranges from 4.0×10^{14} Hz to 7.5×10^{14} Hz. The coherence length for this white light is —
   (A) 8.58×10^{-7} m
   (B) 7.50×10^{-7} m
   (C) 7.0×10^{-7} m
   (D) 8.0×10^{-7} m

6. When the movable mirror of a Michelson's interferometer is moved through a distance 'd', consecutive positions of maximum indistinctness are obtained for sodium light having wavelengths 589.0 nm and 589.6 nm. The value of 'd' is —
   (A) 0.2894×10^{-2} m
   (B) 0.5788×10^{-2} m
   (C) 0.5788×10^{-3} m
   (D) 0.2894×10^{-3} m

7. Two coherent sources of the same frequency have intensities I_0 and $2I_0$. The ratio of maximum intensity to minimum intensity $\left(\frac{I_{max}}{I_{min}}\right)$ in their interference pattern will be —
   (A) 10.0
   (B) 34 (nearly)
   (C) 3.0
   (D) 1.66 (nearly)

8. For a p-n-p transistor, $\alpha = 0.99$. If the input resistance $r_i = 1.0\,\text{k}\Omega$ and the load resistance $R_L = 2.5\,\text{k}\Omega$, find β and the voltage gain (A_v) for the transistor in CE configuration.

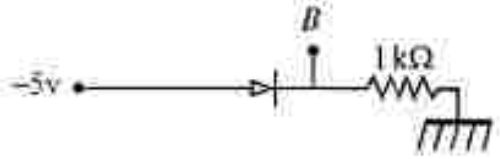
   (A) $\beta = 100$ and $A_v = 250.0$

   (B) $\beta = 99$ and $A_v = 2.475$

   (C) $\beta = 99$ and $A_v = 247.5$

   (D) $\beta = 99$ and $A_v = 39.6$

9. In the following figure, voltage at the point B is



   (A) − 5v

   (B) + 5v

   (C) 1v

   (D) 0v

10. The minimum number of two-input NAND gates required to realise the Boolean function $F = AB + CD$ is —

    (A) two

    (B) three

    (C) four

    (D) five

Turn Over

2017

PHYSICS (Honours)

Paper Code : IV-B

[New Syllabus]

Full Marks : 55 Time : Three Hours Thirty Minutes

The figures in the margin indicate full marks.

Answer *five* questions taking at least *one* from each group.

Any kind of calculator may be used.

Group - A

[Geometrical Optics]

1. (a) Show that the refraction through a spherical surface can be characterised by a 2×2 matrix given by $[R]=\begin{bmatrix}1 & -P\\ 0 & 1\end{bmatrix}$, terms being usual. 3

(b) Consider a plano-convex lens of a material of refractive index 1.5. The convex surface has a radius of curvature of 2.5 cm and is facing the incident light. The central thickness of the lens is 0.6 cm. Construct the system matrix. 4

(c) What do you mean by 'chromatic aberration' ? Find the condition of achromatism of two thin lenses mounted co-axially at a distance apart. The material of the two lenses is identical. 1+3

2. (a) Show that for a telescopic system, angular magnification is equal to the reciprocal of linear magnification. 2

(b) In what ways is a reflecting telescope superior to a refracting one ? 2

(c) Define principal points and nodal points of a thick lens. Show that if the medium on either side of a thick lens be the same, the nodal points coincide with the principal points. 2+4

(d) What do you mean by aplanatic points of a spherical surface ? 1

Group - B

[Physical Optics]

3. (a) Explain how a Lloyd's mirror forms interference fringes. Why is the central fringe of Lloyd's mirror pattern dark ? 3+1

(b) Discuss the production of interference fringes by a thin film in reflected light by the division of amplitude. Obtain the conditions of bright and dark fringes. 4

(c) In Newton's ring experiment with air-film, the diameters of the 3rd and the 23rd dark rings were found to be 0.181 cm and 0.501 cm respectively. If the radius of curvature of the plano-convex lens is 0.5m, calculate the wavelength (in Å) of light used. 3

4. (a) What is a zone plate ? Prove that a zone plate has multiple foci. Compare the actions of a zone plate and a converging lens. 1+2+2

(b) Derive an expression for the intensity of the fringe system formed by the transmitted light in a Fabry-Perot interferometer.

Show that in a Fabry-Perot interferometer the visibility of fringes is given by $V = \frac{2R}{1+R^2}$, terms having usual significance. 4+2

5. (a) State Rayleigh's criterion for the resolution of spectral lines. Find an expression for the resolving power of a plane diffraction grating having N number of rulings. 1+5

(b) A diffraction grating which has 4000 lines per cm is used at normal incidence. Calculate the dispersive power of the grating in the third order spectrum in the wavelength region of 5000 Å. 3

(c) In what ways is a concave grating superior to a plane transmission grating ? 2

6. (a) Discuss the Fraunhofer diffraction due to a single slite, using monochromatic light of wavelength λ. Obtain an expression for the intensity of the diffracted light when a plane wavefront is incident normally on the slit. Deduce the

Turn Over

conditions of principal maxima, minima and secondary maxima. Plot the intensity distribution curve. 1+3+3+1

(b) In a double slit experiment a circular source $(\lambda = 500\ \text{nm})$ is used to illuminate the slits which are 1.0 mm apart. If the source is 10.0 cm from the plane of the slits, find the minimum diameter of the circular source for the interference pattern just to vanish. 3

Group - C

[Electronics - I]

7. (a) Show graphically the forward-bias and the reverse-bias volt-ampere characteristics of a Zener diode. Choose any point on the forward-bias characteristic curve and explain how r_{dc} and r_{ac} corresponding to that point can be calculated.

Explain how zener breakdown occurs. 2+2+2

(b) Draw a circuit diagram of a full-wave rectifier, using two diodes. What are ripples ? How can these be minimised by a π-section filter ? 1+1+3

8. (a) Introduce the hybrid parameters of a transistor operating under CE-configuration. 2

(b) Define α and β of a transistor and prove that $\beta = \frac{\alpha}{1-\alpha}$, terms being usual. 2+1

(c) Draw the circuit diagram of an emitter follower. No description of the circuit is required. 2

(d) Implement the Boolean expression $F = A\overline{B} + \overline{A}B$ into a logic gate circuit and write down the relevant truth table. 4

2017

PHYSICS (Honours)

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3(129 - 700

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Choose the correct answer.

Each question carries $1\frac{1}{2}$ marks.

1. 10 gm of ice at 0°C is melted to water at the same temperature. Latent heat of fusion of ice is 80 cal/gm. The change in entropy for this process is equal to —

   (A) Zero

   (B) $+8.0$ cal K^{-1}

   (C) $+2.93$ cal K^{-1}

   (D) -2.93 cal K^{-1}

2. How much work must be done to extract 10 J of heat from a reservoir at 7°C and transfer it to one at 27°C by means of a refrigerator working in a carnot cycle ?

   (A) 0.71 J

   (B) 0.67 J

   (C) 0.36 J

   (D) 0.33 J

Turn Over

3. The phase equilibrium curve of solid and vapour ammonia is given by $\ln P = 23.03 - \frac{3754}{T}$, and that of liquid and vapour ammonia is given by $\ln P = 19.49 - \frac{3063}{T}$. Then, the triple point of ammonia is —

   (A) 273.16 K

   (B) 195.20 K

   (C) 21.26 K

   (D) 303.16 K

4. A reversible engine works in a Carnot cycle between temperatures of 100°C and 0°C. If the work output in the cycle is 1200 kg.m, the amount of heat in calories absorbed from the source was —

   (A) 4475.9

   (B) 1065.7

   (C) 43864.8

   (D) 10444.0

5. For a general system, it is given that : $\left(\frac{\partial C_p}{\partial p}\right)_T = -T\left(\frac{\partial^2 V}{\partial T^2}\right)$. If the equation of state for a substance is given by $V = \frac{RT}{p} - \frac{C}{T^3}$, where C = constant, $\left(\frac{\partial C_p}{\partial p}\right)_T$ will be proportional to —

(A) T^{-5}

(B) T^{-3}

(C) T^{-4}

(D) T^{-1}

6. A charged particle moves with a uniform velocity $\vec{u} = 4\hat{i}$ ms^{-1} in a region where $\vec{E} = 20\hat{j}$ Vm^{-1} and $\vec{B} = B_0\hat{k}$ tesla. The value of B_0 is —

(A) 5.0 tesla

(B) 80.0 tesla

(C) $\frac{1}{5}$ tesla

(D) None of the above

Turn Over

7. A current distribution gives rise to the magnetic vector potential $\vec{A}(x,y,z) = x^2y\,\hat{i} + y^2x\,\hat{j} - xyz\,\hat{k}$ tesla.m. The corresponding magnetic field $\vec{B}$ at $(-1, 2, 5)$ is given by —

(A) $5\hat{i} + 10\hat{j} - 3\hat{k}$

(B) $5\hat{i} + 10\hat{j} + 3\hat{k}$

(C) $-5\hat{i} + 10\hat{j} + 3\hat{k}$

(D) $-5\hat{i} + 10\hat{j} - 3\hat{k}$

8. When an a.c. voltage is applied to a choke coil, the current lags behind the e.m.f. by a phase angle of $\frac{\pi}{2}$. The power delivered by the coil will be —

(A) a maximum

(B) a minimum (but not zero)

(C) zero

(D) of any value depending on the magnitude of inductance of the coil.

9. A conductor of length 0.4 m is moving with a speed 5 m/s perpendicular to a magnetic field of 1T. The e.m.f. induced across the conductor is

(A) 2.0 volt

(B) 1.0 volt

(C) 0.2 volt

(D) 0.1 volt

10. A coil of self-inductance 100 mH is connected in series with another coil of self-inductance 200 mH. The effective inductance of the combination is found to be 120 mH. The mutual inductance between the coils has a value of —

(A) 180 mH

(B) 90 mH

(C) 220 mH

(D) 20 mH

2017

PHYSICS (Honours)

Paper Code : V-B

[New Syllabus]

Full Marks : 55 Time : Three Hours Thirty Minutes

The figures in the margin indicate full marks.

Answer *five* questions, taking at least *two* from each group.

(Any kind of Calculator may be used.)

Group - A

[Thermodynamics]

1. (a) State the law which is the basis of the measurement of temperature by a thermometer. 1

(b) How would you justify that the work done (dW) by a thermodynamic system is an imperfect differential ? 2

(c) For an ideal gas, if E_T and E_S denote respectively the isothermal and the adiabatic moduli of elasticity, prove that $\frac{E_S}{E_T} = \gamma$, where γ is the ratio of the two specific heats of the gas. 3

(d) If $f(p, V, T) = 0$, prove that $\left(\frac{\partial p}{\partial V}\right)_T \left(\frac{\partial V}{\partial T}\right)_p \left(\frac{\partial T}{\partial p}\right)_V = -1$ 2

(e) The efficiency of a Carnot engine can be increased either by increasing the source temperature or by lowering the sink temperature. Show analytically which one is the more effective way. 3

2. (a) Calculate the change in entropy when two dissimilar ideal gases undergo diffusion under the same conditions of temperature and pressure. What is Gibbs' paradox ? 3+1

(b) At N.T.P. 8.4 litre of oxygen and 14.0 litre of hydrogen mix up completely. Taking R = 2.0 cal $mole^{-1}$ K^{-1} and assuming the gases to be ideal, show that the change in entropy in this diffusion process is approximately 1.32 cal K^{-1}. 3

(c) What is Joule-Thomson effect ? Show that the Joule-Thomson coefficient (μ) is given by $\mu = \frac{1}{C_P}\left[T\left(\frac{\partial V}{\partial T}\right)_P - V\right]$. 1+3

3. (a) What is meant by first order phase transition ? Deduce Clapeyron's equation for the first order phase transition. 1+2

(b) Latent heat L satisfies an equation :

$L = (596.73 - 0.601\ t)$ at t°C. Calculate the specific heat of saturated steam at 100°C. Specific heat of water of 100°C is 1.007 cal gm^{-1}. Explain the significance of your result. 3+1

(c) What is adiabatic demagnetisation ? Describe briefly how it has been used to produce very low-temperature. 1+3

4. (a) Prove the energy equation : $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$, terms being usual. Show that for 1 mole of a van der Waals' gas, $\left(\frac{\partial U}{\partial V}\right)_T = \frac{a}{V^2}$. 2+1

Turn Over

(b) Show that for an isentropic transformation

$$\left(\frac{\partial V}{\partial T}\right)_S = -\frac{C_V}{C_P - C_V}\left(\frac{\partial V}{\partial T}\right)_P$$ 3

(c) Represent the different strokes of a Diesel cycle on a $P - V$ diagram and find an expression for its efficiency. 5

Group - B

[Electricity - II]

5. (a) Write down the differential form of Ampere's circuital theorem. Hence, convert it into the usual integral form. 1+2

(b) A proton and a deuteron moving with equal Kinetic energy enter into a steady magnetic field $\vec{B}$ held normal to their paths. If r_p and r_d be the respective radii of their circular tracks, find $r_p : r_d$ 3

(c) A d.c. source of e.m.f. is suddenly applied to a circuit consisting of a resistor R, an inductor L and a capacitor C connected in series. Investigate the oscillatory growth of charge in the capacitor. 5

6. (a) State the two laws of thermoelectricity. What is negative Thomson effect ? A thermocouple is comprised by two metals X and Y. Prove that $\pi = T\frac{dE}{dT}$ and $\sigma_X - \sigma_Y = -T\frac{d^2E}{dT^2}$, terms being usual. 2+1+4

(b) An electron moves in a circular orbit of radius 0.51 Å round a nucleus at a frequency of 6.8×10^{15} Hz. Find the magnetic induction at the nucleus and the equivalent magnetic moment. Given :

electronic charge $= 1.6\times10^{-19} C$ and $\mu_0 = 4\pi\times10^{-7}$ H.m^{-1}. 4