TDP (General) 1st Semester Exam., 2015

PHYSICS
(General)

FIRST PAPER

Full Marks : 40

Time : 2 hours

The figures in the margin indicate full marks for the questions

Answer **all** questions

1. (a) (i) State Gauss' divergence theorem in vector calculus.

(ii) If $r^2 = x^2 + y^2 + z^2$, then prove that

$$\vec{\nabla} r^n = n r^{n-1} \hat{r}$$

(iii) Show that $\oint \vec{r} \cdot d\vec{S} = 3V$, where V is the volume enclosed by the closed surface S.

(iv) The velocity of a particle moving in a plane is given as

$$\vec{V} = \dot{r}\hat{r} + r\dot{\theta}\hat{\theta}$$

Using this, show that

$$\vec{a}_r = (\ddot{r} - r\dot{\theta}^2)\hat{r} \text{ and } \vec{a}_\theta = (r\ddot{\theta} + 2\dot{r}\dot{\theta})\hat{\theta}$$

where the symbols have their usual meanings. 2+3+2+3=10

Or

(b) (i) State and prove parallel axes theorem as applied to moment of inertia. 8-3

(ii) Write the Lagrange's equation of motion for a system. Derive the equation of motion for a simple pendulum using Lagrange's equation. 8-15 (2+3)+(1+4)=10

2. (a) (i) Derive an expression for the gravitational potential at a point outside ($r > R$) a hollow sphere of radius R and mass M.

(ii) Obtain an expression for the height h through which a liquid of surface tension T will rise in a capillary tube of radius r.

(iii) N identical raindrops are falling through air with a velocity v each. If they combine together to form a large drop, then what will be its terminal velocity? 4+4+2=10

Or

(b) (i) Prove that for a cantilever of length l and carrying a load W at its free end, the depression at the free end will be

$$\delta = \frac{Wl^3}{3Yl}$$

where the symbols have their usual meanings.

(ii) If a liquid drop of radius R breaks up into n number of small similar drops, then show that the loss of energy will be

$$\Delta U = 4\pi R^2 T(n^{1/3} - 1)$$

where, T is the surface tension

(iii) State Stokes' law in connection with the motion of a small spherical body through a viscous medium.

5+3+2=10

3. (a) (i) Establish the relation between Boyle temperature (T_B) and critical temperature (T_C) for a van der Waals gas.

(ii) State and prove Carnot's theorem.

(iii) "Entropy is a measure of the so-called unavailable energy." Explain.

(iv) State Newton's law of cooling. 3+3+2+2=10

Or

(b) (i) Show that the entropy of a system increases during an irreversible process.

(ii) Prove that the Joule-Thomson coefficient (μ) for a van der Waals gas is

$$\mu = \frac{1}{C_p}\left[\frac{2a}{RT} - b\right]$$

where the symbols have their usual meanings.

(iii) What is 'temperature of inversion'?

(iv) A full radiator at 400 K radiates energy at the rate of $1{\cdot}45\times10^{3}$ W-m^{-2}. Obtain the value of Stefan's constant. 3+4+1+2=10

4. (a) (i) State Fermat's principle. How can you establish the laws of reflection from this principle?

(Continued)

(ii) Establish the relation

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{r}$$

for a spherical refracting surface. The symbols in the relation have their usual meanings.

(iii) What is double refraction?

(1+3)+4+2=10

Or

(b) (i) Derive an expression for the width of fringe produced due to interference in Young's double slit experiment.

(ii) Compare between a 'zone plate' and a 'convex lens'.

(iii) Newton's rings are observed in reflected light of $\lambda = 5{\cdot}9 \times 10^{-7}$ m. The diameter of 10th dark ring is 0·5 cm. Find the radius of curvature of the lens and the thickness of the airfilm corresponding to the dark ring.

4+3+3=10

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TDP (General) 1st Semester Exam., 2016

PHYSICS

(General)

FIRST PAPER

Full Marks : 40

Time : 2 hours

The figures in the margin indicate full marks for the questions

Answer **four** questions, taking **one** from each Unit

UNIT—I

1. (a) State Stokes' theorem.

(b) Find the value of $\nabla^2\left(\frac{1}{r}\right)$.

(c) Calculate the moment of inertia of a solid sphere of mass M and radius R about its diameter. 2+3+5=10

2. (a) Derive the equation of trajectory of a projectile thrown at angle α with respect to horizontal with initial velocity u_0.

(b) What is meant by 'degree of freedom'?

(c) What is cyclic coordinate? State its significance. 5+2+(2+1)=10

UNIT—II

3. *(a)* Derive an expression for the gravitational potential at a point inside ($r < R$) of a solid sphere of radius R and mass M.

(b) Establish the relation $Y = 3k(1-2\sigma)$, where symbols have their usual meanings. 5+5=10

4. *(a)* Derive an expression for the height through which liquid rises in a capillary tube. State Jurin's law.

(b) A copper wire 3 m long for which Young's modulus $12 \cdot 5 \times 10^{12}$ Nm^{-2} has a diameter of 1 mm. If a weight of 10 kg is attached to one end, what extension is produced? (5+1)+4=10

UNIT—III

5. *(a)* Establish the relation

$$\frac{RT_c}{P_c V_c} = \frac{8}{3}$$

where the symbols have their usual meanings.

(b) What is 'thermal death'?

(c) Find the change in entropy when 1 kg of ice converts into steam. 5+2+3=10

 (Continued)

6. (a) Give *P-V* diagram of a Carnot's cycle and hence calculate its efficiency.

(b) Define 'emissive and absorptive power' in connection with blackbody radiation.

(c) What is diffused radiation? (1+4)+4+1=10

UNIT—IV

7. (a) Discuss the working of Huygens' eyepiece.

(b) State the advantages of Ramsden's eyepiece over Huygens' eyepiece.

(c) A zone plate with radius 0·4 mm of the first zone is mounted on an optical bench 42 cm from a pinhole illuminated by green light of wavelength 5460 Å. Find the distance of the primary image. 4+2+4=10

8. (a) Differentiate between Fresnel class and Fraunhofer class of diffraction.

(b) Draw the intensity distribution for diffraction due to single slit.

(c) Why are the fringes produced by a biprism called non-localized fringes?

(d) Why is the central fringe of Newton's ring dark? In case of white light, the fringes are coloured. Why? 3+1+2+(2+2)=10

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TDP (General) 1st Semester Exam., 2017

PHYSICS

(General)

FIRST PAPER

Full Marks : 40

Time : 2 hours

The figures in the margin indicate full marks for the questions

Answer **four** questions, taking **one** from each Unit

UNIT—I

1. (a) State Gauss's divergence theorem on vector calculus.

(b) State parallel axes theorem. Calculate the moment of inertia of a cylinder about an axis perpendicular to its own axis.

(c) Show that $\nabla r^n = nr^{n-2}\vec{r}$. 2+(2+3)+3=10

2. (a) Find the radial and cross-radial components of acceleration of a particle moving in a plane.

(b) What is generalized momentum?

(c) Write the Lagrangian and hence deduce the equation of motion for a simple pendulum. 5+2+3=10

UNIT—II

3. (a) A rectangular beam clamped at one end and loaded at the other end. Show that the depression at the loaded end is given by $\delta = \frac{4Wl^3}{Ybd^3}$, where symbols have their usual meanings.

(b) Derive the expressions for the gravitational potential and intensity at a point outside a thin spherical shell of mass M and radius r.

(c) Define neutral surface. 5+4+1=10

4. (a) Discuss how one can measure the rate of flow of liquid using a venturi meter.

(b) If a liquid drop of radius R breaks into n number of small identical drops, then find the loss of energy. Given surface tension of liquid is T.

(c) State Stokes' law.

(d) How does surface tension of a liquid vary with temperature? 4+3+2+1=10

UNIT—III

5. (a) State second law of thermodynamics.

(b) A gas follows the equation $p(V - b) = RT$. Calculate the change in entropy when it undergoes a change of volume V_1 (at T_1) to a volume V_2 (at T_2).

(c) State Stefan-Boltzmann law of radiation. Establish Newton's law of cooling from it.

(d) Write van der Waals' equation for n moles of a real gas. 2+3+(2+2)+1=10

6. (a) State and prove Carnot's theorem.

(b) What is Joule-Thomson effect? Show that in J-T experiment, the enthalpy of the gas remains constant. (2+3)+(2+3)=10

UNIT—IV

7. (a) Establish the laws of refraction of light using Fermat's principle.

(b) Considering refraction from a spherical surface, derive the equation,

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

where the symbols have their usual meanings.

(c) Find the focal length of the combination of two lenses of focal lengths + 10 cm and + 25 cm separated by a distance of 5 cm. 4+4+2=10

8. (a) When are two sources said to be coherent to each other?

(b) Derive an expression for the width of fringe in interference.

(c) Explain double refraction.

(d) Define zone plate. 2+4+2+2=10

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TDP (General) 1st Semester Exam., 2018

PHYSICS

(General)

FIRST PAPER

Full Marks : 40

Time : 2 hours

The figures in the margin indicate full marks for the questions

Answer **four** questions, taking **one** from each Unit

UNIT—I

1. (a) If $\varphi = \exp(xyz)$, then find grad φ.

(b) State Stokes' theorem.

(c) What is meant by moment of inertia? Find the moment of inertia of a thin uniform rod rotating about an axis passing through its centre and perpendicular to it.

(d) Define cyclic coordinate. 2+2+(1+3)+2=10

2. (a) Prove that div curl $\vec{A} = 0$.

(b) State and explain the theorem of perpendicular axes in relation to moment of inertia.

(c) The Lagrangian of a system is given by $L = \frac{1}{2}\alpha\dot{q}^2 - \frac{1}{2}\beta q^2$, where α and β are two constants. Obtain the equation of motion and also the Hamiltonian.

3+(1+3)+3=10

UNIT—II

3. (a) Derive the expression for the gravitational potential and intensity at a point inside a thin spherical shell of mass M and radius r.

(b) If the rigidity modulus and Young's modulus of a material are 8×10^{11} N/m^2 and 20×10^{11} N/m^2 respectively, then find the Poisson's ratio.

(c) State Jurin's law.

(d) Derive Poiseuille's equation for the flow of an incompressible liquid. 4+2+1+3=10

4. (a) Derive an expression for the couple required to twist a uniform solid cylinder by an angle.

(Continued)

(b) Define terminal velocity.

(c) Draw the variation of gravitational potential (V) and intensity (E) as function of distance (r) from the centre of a uniform solid sphere.

(d) Calculate the excess pressure inside a soap bubble of radius 3 mm. Surface tension of soap solution is 20×10^{-3} N/m. Also calculate the surface energy. 4+1+2+3=10

10

UNIT—III

5. (a) State and prove Kirchhoff's law of radiation.

(b) Calculate the maximum efficiency of a heat engine operating between 0 °C and 100 °C.

(c) Define entropy. Show that the change in entropy for a reversible cycle is zero. (1+3)+2+(1+3)=10

6. (a) Define Joule-Thomson effect and inversion temperature.

(b) What is Boyle temperature?

(c) State and prove Carnot's theorem.

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(d) If there is no wastage of energy in Carnot's engine, then why is the efficiency of the engine less than 100%?

3+1+(1+3)+2=10

UNIT—IV

7. (a) Distinguish between diffraction and interference.

(b) What are positive and negative zone plates?

(c) Discuss Fraunhofer diffraction at a double slit. Derive an expression for the intensity distribution and find the positions of maxima and minima.

2+2+(3+3)=10

8. (a) State Fermat's principle. Using it, establish the laws of reflection of light.

(b) Two thin convex lenses having focal lengths of 0·05 m and 0·02 m are coaxial and separated by a distance of 0·03 m. Find the equivalent focal length.

(c) What is Nicol prism? (1+4)+3+2=10

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S–1/PHSG/01/19

TDP (General) 1st Semester Exam., 2019

PHYSICS

(General)

FIRST PAPER

Full Marks : 40

Time : 2 hours

The figures in the margin indicate full marks for the questions

Answer **four** questions, taking **one** from each Unit

UNIT—I

1. *(a)* State Green's theorem in plane and write its mathematical form.

(b) Evaluate $\vec{\nabla}\varphi$, where φ is scalar function given by $\varphi = \frac{1}{r}$.

(c) If $\vec{v} = \vec{\omega} \times \vec{r}$, then show that

$$\vec{\omega} = \frac{1}{2}\vec{\nabla} \times \vec{v}$$

where $\vec{\omega}$ is a constant vector. 2+4+4=10

2. *(a)* Calculate the moment of inertia of a solid cylinder about an axis through its centre and perpendicular to its length.

(b) What are generalized coordinates?

(c) A pendulum with a bob of mass m and length l, is suspended from a massless spring of spring constant k. The spring has only vertical motion. Find the Lagrangian and Lagrange's equation of motion. 3+2+(2+3)=10

UNIT—II

3. *(a)* The mass of the moon is about 8% of the mass of the earth and diameter is about 25% that of the earth. Find the acceleration due to gravity on the surface of the moon.

(b) Find an expression for the work done in stretching a wire and hence energy per unit volume of the wire.

(c) A wire of length 1 m, diameter 10^{-3} m is firmly fixed at its one end. If a couple of 0·5 N-m is applied to the other end of the wire and twisted the wire by an angle 45°, then find the modulus of rigidity of the material of the wire.

3+(3+1)+3=10

(Continued)

4. *(a)* Define surface tension of a liquid. Mention the factors that affecting the surface tension of a liquid.

(b) State Jurin's law and mention its limitations.

(c) Define terminal velocity. Find the terminal velocity of an oil-drop of density $1\,g/cm^3$ and radius 10^{-4} cm falling through air of density $0\cdot0013\,g/cm^3$, if the viscosity of the air is $1\cdot81\times10^{-4}$ c.g.s. unit.

(1+2)+(2+1)+(1+3)=10

UNIT—III

5. *(a)* In what respect, a real gas differs from an ideal gas?

(b) What is Boyle temperature?

(c) In a Carnot's engine, the temperature of source and sink are 227 °C and 102 °C respectively. If the engine consumes 600×10^5 cals per cycle, find its efficiency and work done per cycle.

(d) Define reversible and irreversible changes with example. 2+1+4+3=10

6. (a) Write van der Waals' equation of state for real gas.

(b) State second law of thermodynamics.

(c) Define Thomson effect and inversion temperature.

(d) What is entropy? Show that change in entropy in a Carnot's cycle is zero.

1+2+2+(1+4)=10

UNIT—IV

7. (a) State Fermat's principle. Using it establish Snell's law of refraction of light.

(b) Two convex lenses of focal lengths 10 cm and 20 cm are placed 5 cm apart in air. Find equivalent focal length.

(c) Name the cardinal points of a lens.

(1+4)+3+2=10

8. (a) Explain clearly Huygens' principle for propagation of light.

(b) Define double refraction.

(c) Discuss Fraunhofer diffraction pattern due to a single slit. Derive the condition for production of maxima and minima.

3+2+5=10

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TDP (General) 1st Semester Exam., 2021
(Held in 2022)

PHYSICS
(General)

FIRST PAPER

Full Marks : 80

Time : 3 hours

The figures in the margin indicate full marks for the questions

SECTION—A

1. Answer *all* questions : 2×20=40

(a) Define gradient of a scalar function.

(b) For what value of x, the vector $\vec{A} = \hat{i} + x\hat{j} + \hat{k}$ will be perpendicular to the vector $\vec{B} = 3\hat{i} - 2\hat{j} - 2\hat{k}$?

(c) What is radius of gyration?

(d) Write the unit and dimension of angular momentum.

(e) What is Lagrangian of a system?

(f) Define gravitational potential.

(g) What is escape velocity? Is it same for heavy and light objects?

(h) Define Young's modulus and Poisson's ratio.

(i) What are the factors on which surface tension of a liquid depends?

(j) What is geostationary satellite?

(k) What is the significance of Reynolds' number?

(l) What is degrees of freedom?

(m) Define entropy.

(n) What is Joule-Thomson effect?

(o) State Carnot's theorem.

(p) What is a wavefront?

(q) If the phase difference between two waves is π, what will be their path difference?

(r) What are half-period zones?

(s) What do you understand by Fresnel diffraction?

(t) What is a plane diffraction grating?

SECTION—B

Answer **four** questions, taking **one** from each Unit

UNIT—I

2. (a) State Gauss's divergence theorem and write its mathematical form.

(b) Prove that $\vec{\nabla} r^n = nr^{n-2}\vec{r}$, where $\vec{r}$ is the position vector.

(c) What is irrotational vector? Show that $\vec{A} = (4xy - z^3)\hat{i} + 2x^2\hat{j} - 3xz^2\hat{k}$ is an irrotational vector. 2+4+4=10

3. (a) What is moment of inertia? Calculate the moment of inertia of a solid sphere rotating about any of its diameters.

(b) What is cyclic coordinate?

(c) Lagrangian of a system is $L = \frac{1}{2} m(\dot{r}^2 + r^2\dot{\theta}^2) - mgr\sin\theta$. Find the equations of motion. (1+3)+2+4=1

UNIT—II

4. (a) Derive an expression for the gravitational potential at a point inside ($r < R$) of a solid sphere of radius R and mass M.

(b) Obtain the expression for the height h through which a liquid of surface tension T will rise in a capillary tube of radius r.

(c) N identical raindrops are falling through air with a velocity v each. If they combine together to form a large drop, then what will be its terminal velocity? 4+4+2=10

5. (a) Prove that for a cantilever of length l and carrying a load W at its free end, the depression at the free end will be

$$\delta = \frac{Wl^3}{3YI}$$

where the symbols have their usual meanings.

(b) If a liquid drop of radius R breaks up into n number of small similar drops, then show that the loss of energy will be

$$\Delta U = 4\pi R^2 T(n^{1/3} - 1)$$

where T is the surface tension.

(c) Define terminal velocity. 5+3+2=10

UNIT—III

6. (a) What is the significance of inversion temperature in liquefaction of gases?

(b) What are the differences between J-T expansion and adiabatic expansion?

(c) What is a Carnot engine? What are its characteristics? Is Carnot cycle reversible?

(d) The temperature of heat sink of a Carnot engine is 7 °C and its efficiency is 40%. The efficiency of the engine is to be increased to 50%. What should be the rise of temperature of the heat reservoir of engine for this purpose?

2+2+(1+1+1)+3=10

7. (a) Define 'emissive and absorptive power' in connection with black-body radiation.

(b) State Stefan-Boltzmann law of radiation. Establish Newton's law of cooling from it.

(c) What is diffused radiation? 4+(2+2)+2=10

UNIT—IV

8. (a) Establish the laws of reflection of light on the basis of Huygen's principle.

(b) Prove the total internal reflection of light on the basis of wave theory of light.

(c) Why is Huygen's eyepiece called a negative eyepiece and Ramsden's eyepiece a positive eyepiece?

(d) A convex lens of focal length 20 cm and a concave lens of focal length 30 cm are placed 10 cm apart. Find the focal length of equivalent lens. 3+3+2+2=10

9. (a) Differentiate between Fresnel class and Fraunhofer class of diffraction.

(b) Why is the central fringe of Newton's ring dark? In case of white light, the fringes are coloured, why?

(c) Considering refraction from a spherical surface, derive the equation

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

where the symbols have their usual meanings. 2+(2+2)+4=10

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