11105

No. of Printed Pages: 4

Register Number

11 REVISION EXAMINATION (NUMERICAL PROBLEMS) – FEBRUARY 2023

PART – III

PHYSICS

Time Allowed : 3.00 Hours] [Maximum Marks : 70

Instructions : (1) Check the question paper for fairness of printing. If there is any lack of fairness, inform the Hall Supervisor immediately.

(2) Use **Blue** or **Black** ink to write and underline and pencil to draw diagrams.

PART – II

Note : Answer **All the** questions. 14x2=28

1. A car takes a turn with the velocity 50 ms^{-1} on a circular road of radius of curvature 10 m. Calculate the centrifugal force experienced by a person of mass 60 kg inside the car. **[MARCH – 2019]**

2. The surface tension of a soap solution is 0.03 Nm^{-1}. How much work is done in producing soap bubble of radius 0.05 m? **[MARCH – 2019]**

3. Calculate the value of orbital velocity for an artificial satellite of earth orbiting at a height of 1000 km (Mass of the earth = $6x10^{24}$ kg, radius of the earth = 6400 km). **[MARCH – 2019]**

4. During a cyclic process, a heat engine absorbs 500 J of heat from a hot reservoir, does work and ejects an amount of heat 300 J into the surroundings (cold reservoir). Calculate the efficiency of the heat engine. **[MARCH – 2020, AUGUST - 2022]**

5. If the length of the simple pendulum is increased by 44% from its original length, calculate the percentage increase in time period of the pendulum. **[MARCH – 2020]**

6. The position vector and angular velocity vector of a particle executing uniform circular motion at an instant are $2\hat{\imath}$ and $4\hat{k}$ respectively. Find its linear velocity at that instant. **[SEPTEMBER – 2020]**

7. A metal cube of side 0.20 m is subjected to a shearing force of 4000 N. The top surface is displaced through 0.50 cm with respect to the bottom. Calculate the shear modulus of elasticity of the metal. **[SEPTEMBER – 2020]**

[Turn Over

8. Two objects of masses 2 kg and 4 kg are moving with same momentum of 20 $kgms^{-1}$.
   (A) Will they have same kinetic energy?
   (B) Will they have same speed? **[SEPTEMBER – 2020]**

9. In a submarine equipped with sonar, the time delay between the generation of a pulse and its echo after reflection from an enemy submarine is observed to be 80 sec. If the speed of sound in water is 1460 ms^{-1}, what is the distance of enemy submarine? **[MAY – 2022]**

10. A particle moves along the x-axis in such a way that its coordinates x varies with time 't' according to equation x=2–5t+6t?. What is the initial velocity of the particle? **[MAY – 2022]**

11. A mobile phone tower transmits a wave signal of frequency 900 MHz. Calculate the length of the waves transmitted from the mobile phone tower. **[AUGUST - 2022]**

12. Consider two trains A and B moving along parallel tracks with same velocity in the same direction. Let the velocity of each train be 50 km / hr due east. Calculate the relative velocities of the trains. **[AUGUST - 2022]**

13. If two objects of masses 2.5 kg and 100 kg experience the same force 5 N, what is the acceleration experienced by each of them?

14. Consider a circular leveled road of radius 10 m having coefficient of static friction 0.81. Three cars (A, B and C) are travelling with speed 7 m s^{-1}, 8 m s^{-1} and 10 ms^{-1} respectively. Which car will skid when it moves in the circular level road? ($g = 10\ m\ s^{-2}$)

PART – III

Note : Answer **All the** questions. 14x3=42

15. What is the torque of the force $\vec{F} = 3\hat{\imath} - 2\hat{\jmath} + 4\hat{k}$ acting at a point $\vec{r} = 2\hat{\imath} + 3\hat{\jmath} + 5\hat{k}$ about the origin? **[MARCH – 2019]**

16. Find the rotational kinetic energy of a ring of mass 9 kg and radius 3m rotating with 240 rpm about an axis passing through its centre and perpendicular to its plane. **[MARCH – 2019]**

17. Two waves of wavelength 99 cm and 100 cm both travelling with the velocity of 396 ms^{-1} are made to interfere. Calculate the number of beats produced by them per sec. **[MARCH – 2019]**

18. A ball is thrown vertically upwards with the speed of 19.6 ms^{-1} from the top of a building and reaches the earth in 6 s. Find the height of the building. **[MARCH – 2019]**

19. An object is thrown with initial speed 5ms^{-1} with an angle of projection 30^0. Calculate the maximum height reached and the horizontal range. **[MARCH – 2020]**

20. A force of $(4\hat{\imath} - 3\hat{\jmath} + 5\hat{k})$ N is applied at a point whose position vector is $(7\hat{\imath} + 4\hat{\jmath} - 2\hat{k})$m. Find the torque of force about the origin. **[MARCH – 2020]**

21. From a point on the ground, the top of a tree is seen to have an angle of elevation 60^0. The distance between the tree and a point is 50 m. Calculate the height of the tree. **[MARCH – 2020]**

22. A train was moving at the rate of 54 kmh^{-1} when brakes were applied. It came to rest within a distance of 225 m. Calculate the retardation produced in the train. **[SEPTEMBER – 2020]**

23. Suppose we go 200 km above and below the surface of the Earth, what are the g values at these two points? In which case, is the value of g small? **[SEPTEMBER – 2020]**

24. Calculate the amplitude, angular frequency, frequency, time period and initial phase of the simple harmonic oscillation for the given equation y = 0.3 sin (40πt + 1.1). **[SEPTEMBER – 2020]**

[**Turn Over**

25. Express 76 cm of mercury pressure in terms of Nm^{-2} using the method of dimensions. **[SEPTEMBER – 2020]**
26. What are the resultants of the vector product of two vectors given by $\vec{A} = 4\hat{\imath} - 2\hat{\jmath} + \hat{k}$ and $\vec{B} = 5\hat{\imath} + 3\hat{\jmath} - 4\hat{k}$? **[MAY - 2022]**
27. A person docs 30 kJ work on 2 kg of water by stirring using a paddle wheel. While stirring, around 5 kcal of heat is released from water through its container to the surface and surroundings by thermal conduction and radiation. What is the change in internal energy of the system? **[MAY - 2022]**
28. An electron of mass 9.1×10^{-31} kg revolves around a nucleus in a circular orbit of radius 0.53Å. What is the angular momentum of the electron? (Velocity of electron $v=2.2 \times 10^{6}\ ms^{-1}$) **[AUGUST - 2022]**

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REVISION EXAMINATION (NUMERICAL PROBLEMS) – FEBRUARY 2023

ANSWER KEY

PART – II

Note : Answer **All the** questions. 14x2=28

1. Centrifugal force is given by, $F_{cf} = \frac{mv^2}{r}$; $= \frac{60 \times 50 \times 50}{10}$; = 6 x 2500

   F_{cf} =15000 N

2. Work dome = total surface area x surface tension

   W = 2 x 4πr^2 x T ; = 2 x 4 x 3.14 x (0.05)^2 x 0.03

   = 0.0025 x 0.03 x 8 x 3.14

   = 1.884 x 10^{-3} J

3. V = $\sqrt{\frac{GM_e}{R_e+h}}$; = $\sqrt{\frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{(6400+1000) \times 10^3}}$ V = 7.353 kms^{-1}

4. The efficiency of heat engine is given by $\eta = 1 - \frac{Q_L}{Q_H}$; $\eta = 1 - \frac{300}{500}$; $= 1 - \frac{3}{5}$;

   $\eta = 1 - 0.6$; 0.4

   The heat engine has 40% efficiency, implying that this heat engine converts only 40% of the input heat into work.

5. T $\propto \sqrt{l}$; T = constant $\sqrt{l}$

   $\frac{T_f}{T_i} = \sqrt{\frac{1+\frac{44}{100}l}{l}}$; $\sqrt{1.44}$ = 1.2 ;

   Therefore, T_f = 1.2 T_i = T_i + 20% T_i

6. $\vec{L} = \vec{r} \times \vec{\omega}$; $= 2\vec{i} \times 4\vec{k}$; $8\vec{j}$

7. L = 0.20m, F=4000N, x=0.50cm ; =0.005m and Area A = L^2 = 0.04 m^2

   Therefore, $\eta_R = \left(\frac{F}{A}\right) \times \left(\frac{L}{x}\right)$; $= \left(\frac{4000}{0.04}\right) \times \left(\frac{0.20}{0.005}\right)$; **= 4 x 10^6 Nm^{-2}**

8. (a) The kinetic energy of the mass is given by KE $=\frac{P^2}{2m}$

   For the object of mass 2kg, kinetic energy is KE$_1$ = $\frac{(20)^2}{2x2} = \frac{400}{4}$ = 100J

   For the object of mass 4kg, kinetic energy is KE$_2$ = $\frac{(20)^2}{2x4} = \frac{400}{8}$ = 50J

   the kinetic energy of **both masses is not the same.** The kinetic energy of the **heavier object has lesser kinetic energy than smaller mass.**

   (b) As the momentum, p = mv, the two objects **will not have same speed.**

9. v = 80s , v = 1460 ms^{-1}, D = ?

$D = \frac{v\,t}{2} = \frac{1460 \text{ x } 80}{2}$; = 1460 x 40 ; 58400m

D = 58.4km

10. X = 2 – 5t + $6t^2$

Velocity $v = \frac{dx}{dt} = \frac{d}{dt}(2 - 5t + 6t^2)$ or v = –5 + 12t

For initial velocity, t = 0. Initial velocity = –5 ms^{-1}

11. Frequency, f = 900 MHz; = 900 x 10^6 Hz

The speed of wave is c = 3 × $10^8 ms^{-1}$

$\lambda = \frac{v}{f} = \frac{3 \text{ x } 10^8}{900 \text{ x } 10^6}$; = 0.33m

12. Relative velocity of B with respect to A, $v_{BA} = v_B - v_A$

= 50 km h^{-1} + (−50) km h^{-1} ; = 0 km h^{-1}

Similarly, relative velocity of A with respect to B i.e., v_{AB} is also zero.

Thus each train will appear to be at rest with respect to the other.

13. For the object of mass 2.5 kg, the acceleration is a = $\frac{F}{m} = \frac{5}{2.5}$; **= 2ms^{-2}**

For the object of mass 100 kg, the acceleration is a = $\frac{F}{m} = \frac{5}{100}$; **= 0.05ms^{-2}**

14. From the safe turn condition, the speed of the vehicle (*v*) must be less than or equal

$\sqrt{\mu_s rg}$; $v \le \sqrt{\mu_s rg}$; $\sqrt{\mu_s rg} = \sqrt{0.81 \text{ x } 10 \text{ x } 10}$ = 9 ms^{-1}

For car C, $\sqrt{\mu_s rg}$ is less than v

The speed of car A, B and C are 7 ms^{-1}, 8 ms^{-1} and 10 ms^{-1} respectively. The **cars A and B will have safe turns.** But the **car C has speed 10 ms^{-1}** while it turns which exceeds the safe turning speed. Hence, **the car C will skid.**

PART – III

Note : Answer **All the** questions. 14x3=42

15. $\vec{\tau} = \vec{r} \times \vec{F} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 2 & 3 & 5 \\ 3 & -2 & 4 \end{vmatrix}$

$= (12-(-10))\,\hat{\imath} + (15-8)\,\hat{\jmath} + (-4-9)\,\hat{k}$; $\boldsymbol{\vec{\tau} = 22\hat{\imath} + 7\hat{\jmath} - 13\hat{k}}$

16. The rotational kinetic energy is , $KE = \frac{1}{2} I\omega^2$.

The moment of Inertia of the ring is, $I = MR^2$

$I = 9 \times 3^2$; $= 9 \times 9$; $= 81\ kgm^2$

The angular speed of the ring is, $\omega = 240$ rpm ; $= \frac{240 \times 2\pi}{60} rads^{-1}$

$KE = \frac{1}{2} \times 81 \times \left(\frac{240 \times 2\pi}{60}\right)^2$. ; $= \frac{1}{2} \times 81 \times (8\pi)^2$;

$KE = \frac{1}{2} \times 81 \times 64\, (\pi)^2$;

$= 2592 \times (\pi)^2$; $KE \approx 25920J$

KE = 25.920 kJ $[\,(\pi)^2 \approx 10]$

17. Frequency of first wave $f_1 = \frac{v}{\lambda_1} = \frac{396}{0.96}$; Frequency of second wave $f_2 = \frac{v}{\lambda_2} = \frac{396}{1}$

Thus number of beat produced per second $b = f_1 - f_2$; $= 396 \left[\frac{1}{0.99} - \frac{1}{1}\right]$; $b = 4$

18. The ball is thrown upwards with velocity 19.6 m/s. During the upward motion it experiences -9.8 m/s^2 acceleration due to which it comes to rest momentarily at the highest point in air. We can calculate the time taken to reach the highest point.

$v = u + at$; $0 = 19.6 - 9.8\,t$; $t = 2$ sec

So the ball reaches the topmost point in air in 2 seconds.

Distance travelled by the ball until it reaches the highest point:

$s = ut + at^2/2 = 19.6 \times 2 + 9.8 \times 2^2/2$ $s = 19.6\times2 + 19.6 = 19.6\times3 = 58.8$ m

Hence the ball travels 58.8 m above the height of tower after throwing. Now the ball comes down and experiences an acceleration of +9.8 m/s^2.

The time in which it reaches down from the highest point is 4 sec (6-2) because 2 sec is consumed in reaching the highest point.

Now let us calculate the distance travelled by the ball to reach the earth in 4 sec. $s = ut + at^2/2$ $s = 0\times t + 9.8\times 4^2/2$ $s = 9.8\times 8$ m This distance also includes the distance from the throwing point to the highest point, ie 58.8m.

So we need to subtract that distance from this calculated distance of 9.8×8 m. So height of tower = 9.8× 8 - 58.8 = 9.8×8 - 9.8×3 = 9.8×5 = 49 m. Hence height of the tower is 49 m.

19. i) maximum height of the projectile, $h_{max} = \frac{u^2 \sin^2\theta}{2g}$

$h_{max} = \frac{5^2 \sin 30^0 \sin 30^0}{2 \times 9.8}$; = $\frac{25 \times \left[\frac{1}{2}\right] \times \left[\frac{1}{2}\right]}{2 \times 9.8}$; = $\frac{25}{8 \times 9.8}$; = $\frac{25}{78.4}$; **h_{max} = 0.3188m**

ii) Horizontal Range R = $\frac{u^2 \sin 2\theta}{g}$; = $\frac{u^2 2 \sin\theta \cos\theta}{g}$; = $\frac{5^2 \times 2 \sin 30^0 \cos 30^0}{9.8}$

= $\frac{25 \times 2 \left[\frac{1}{2}\right] \times \left[\frac{\sqrt{3}}{2}\right]}{9.8}$; = $\frac{25 \times 1.732}{2 \times 9.8}$ = $\frac{43.300}{19.6}$; **R = 2.21m**

20. $\vec{\tau} = \vec{r} \times \vec{F} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 7 & 4 & -2 \\ 4 & -3 & 5 \end{vmatrix}$

= (20 −6) $\hat{\imath}$ − (35 +8) $\hat{\jmath}$ + (−21−16) $\hat{k}$;

= (14$\hat{\imath}$ − 43$\hat{\jmath}$ − 37 $\hat{k}$) Nm

21. For triangulation method $\tan\theta = \frac{h}{x}$

h = x tan θ ; = 50 × tan 60⁰ ; = 50 × 1.732

h = 86.6 m; **The height of the tree is 86.6 m.**

22. The final velocity of the particle v = 0

The initial velocity of the particle u = 54 x $\frac{5}{18}$ ms^{-1} = 15 ms^{-1} ; s = 225 m

Retardation is always against the velocity of the particle.

$v^2 = u^2 - 2aS$; 0 = $(15)^2$ − 2a (225); 450 a = 225

a = $\frac{225}{450}$ ms^{-2} ; =0.5 ms^{-2} ; **Retardation = =0.5 ms^{-2}**

23. $g' = g\left(1 - \frac{d}{R_E}\right)$; = $\left(1 - \frac{200 \times 10^3}{6371 \times 10^3}\right)$; = g (1 – 0.0314) ; = g (0.9686)

g' =0.96 g

Variation of g' with altitude

$g' = g\left(1 - \frac{2h}{R_E}\right)$; = $\left(1 - \frac{2 \times 200 \times 10^3}{6371 \times 10^3}\right)$; = g (1 – 2(0.0314)) ; = g (0.9372)

g' =0.94 g

24. y = A sin $(\omega t + \varphi_0)$
Amplitude A = 0.3 unit
Angular frequency ω = 40π rad s^{-1}
Frequency f = $\frac{\omega}{2\pi}$; = $\frac{40\pi}{2\pi}$ f = 20 Hz
Time period T = $\frac{1}{f}$; = $\frac{1}{20}$ T = 0.05 sec.
Initial phase φ_0 : 1 : 1 rad

25. In cgs system 76 cm of mercury pressure = 76 × 13.6 × 980 dyne cm^{-2}
The dimensional formula of pressure P is $[ML^{-1}T^{-2}]$

$$P_1[M_1^a L_1^b T_1^c] = P_2[M_2^a L_2^b T_2^c] \; ; \; P_2 = P_1\left[\frac{M_1}{M_2}\right]^a \left[\frac{L_1}{L_2}\right]^b \left[\frac{T_1}{T_2}\right]^c$$

M_1 = 1g, M_2 = 1kg; L_1 = 1 cm, L_2 = 1m; T_1 = 1 s, T_2 = 1s
As a =1, b= -1, and c = -2

$$\text{Then } P_2 = 76 \times 13.6 \times 980 \left[\frac{1kg}{1kg}\right]^1 \left[\frac{1cm}{1m}\right]^{-1} \left[\frac{1s}{1s}\right]^{-2}$$

$$= 76 \times 13.6 \times 980 \left[\frac{10^{-3}kg}{1kg}\right]^1 \left[\frac{10^{-2}m}{1m}\right]^{-1} \left[\frac{1s}{1s}\right]^{-2}$$

= 76 × 13.6 × 980 × $[10^{-3}]$ × 10^2
P_2 = 1.01 × 10^5 Nm^{-2}

26. $\vec{A} \times \vec{B} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 4 & -2 & 1 \\ 5 & 3 & -4 \end{vmatrix}$
= (8 – 3) $\hat{\imath}$ + (5+16) $\hat{\jmath}$ + (12 + 10) $\hat{k}$;
$\vec{A} \times \vec{B}$= $5\hat{\imath} + 21\hat{\jmath} + 22\hat{k}$

27. Work done on the system (by the person while stirring), W = −30 kJ = −30,000J
Heat flowing out of the system, Q = −5 kcal = −5×4184 J =−20920 J
Using First law of thermodynamics, ΔU = Q−W
ΔU = −20,920 J− (−30,000) J
ΔU = −20,920 J+30,000 J = 9080 J
Here, the heat lost is less than the work done on the system, so the change in internal energy is positive.

28. Angular momentum of electron L = mvr
9.1 x 10^{-31} x 2.2 x 10^6 x 0.53 x 10^{-10}
10.61 x 10^{-35} $kgms^{-2}$

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