B.K. BIRLA CENTRE FOR EDUCATION

SARALA BIRLA GROUP OF SCHOOLS

A CBSE DAY-CUM-BOYS' RESIDENTIAL SCHOOL

TERM-1 EXAMINATION (2025-26)

PHYSICS (042) (SET-I)

MARKING SCHEME

Class: XI **Time: 3hr**

Date: 12.02.26 **Max Marks: 70**

Section A (16 X 1M)

1. **(a) [$ML^{-1}T^{-2}$]**
2. **(d) Speed**
3. **(b) 45°**
4. **(a) Their ranges are the same**
5. **(c) Watt**
6. **(b) KE = 1/2 Iω^2**
7. **(d) All of these**
8. **(c) Two times**
9. **(c) Water**
10. **(a) 4°C**
11. **(a) 295 cal**
12. **(a) 19 J**
13. **(a)** (Both true & Reason correctly explains Assertion)
14. **(b)** (Both true but Reason is not the correct explanation)
15. **(b)** (Both true but Reason is not the correct explanation)
16. **(c)** (Assertion true but Reason false)

Section-B (5 X 2M)

17. **(a) Projectile time of flight**

Given: $u = 20\, m/s, \theta = 60^\circ$

$$T = \frac{2u\sin\,\theta}{g}$$

$$T = \frac{2(20)\sin\,60^\circ}{9.8} = \frac{40 \times \frac{\sqrt{3}}{2}}{9.8} = \frac{20\sqrt{3}}{9.8} \approx 3.53\, s$$

Time of flight = 3.53 s

OR

(b) Car retardation

Given: $u = 126\ km/h = 35\ m/s,\ v = 0,\ s = 200m$

Using:

$$v^2 = u^2 + 2as$$
$$0 = (35)^2 + 2a(200) \Rightarrow 0 = 1225 + 400a \Rightarrow a = -3.06\ m/s^2$$

Time:

$$v = u + at \Rightarrow 0 = 35 - 3.06t \Rightarrow t = 11.44\ s$$

Retardation = $3.06\ m/s^2$

Time taken = $11.44s$

18. **Newton's Third Law of Motion (2 marks)**

Statement: *For every action, there is an equal and opposite reaction.*

Explanation: If body A exerts a force Fon body B (action), then body B exerts an equal force Fon body A in the opposite direction (reaction). These forces act on different bodies, so they do not cancel each other.

Example: When we walk, we push the ground backward, and the ground pushes us forward.

19. **Work-Energy Theorem (Variable Force) – Statement & Proof (2 marks)**

Statement: *The work done by a force on a body is equal to the change in its kinetic energy.*

Proof (for variable force):

Small work done,

$$dW = F\,dx$$

But $F = ma$and $a = v\frac{dv}{dx}$

$$dW = m\left(v\frac{dv}{dx}\right)dx = mv\,dv$$

Integrating:

$$W = \int mv\,dv = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

Hence,

$$W = \Delta K$$

(work done = change in kinetic energy)

20. Work done in Isothermal Process (2 marks)

In **isothermal process**, **temperature remains constant**.

$$W = \int_{V_1}^{V_2} P\, dV$$

For an ideal gas in isothermal condition:

$$P = \frac{nRT}{V}$$

So,

$$W = \int_{V_1}^{V_2} \frac{nRT}{V}\, dV = nRT\ln\left(\frac{V_2}{V_1}\right)$$

Final expression:

$$W = nRT\ln\left(\frac{V_2}{V_1}\right)$$

21. Heartbeat Frequency and Time Period (2 marks)

Given: Heartbeat = **75 beats per minute**

Frequency:

$$f = \frac{75}{60} = 1.25\ Hz$$

Time Period:

$$T = \frac{1}{f} = \frac{1}{1.25} = 0.8\ s$$

Frequency = 1.25 Hz
Time period = 0.8 s

SECTION-C (7 X 3M)

22. Dimensional formula of kinetic energy (3 marks)

Given:

$$K = \frac{1}{2}mv^2$$

Dimensions:

- Mass $m = [M]$
- Velocity $v = [LT^{-1}]$

So,

$$\boldsymbol{K = [M]\,[LT^{-1}]^2 = [M][L^2T^{-2}]}$$

Dimensional formula of kinetic energy:

$$\boxed{[\boldsymbol{ML^2T^{-2}}]}$$

23. Derive three equations of motion (Graphical method) (3 marks)

Draw velocity–time graph for uniformly accelerated motion.

(i) First equation: $\boldsymbol{v = u + at}$

Slope of v–t graph = acceleration:

$$a = \frac{v-u}{t} \Rightarrow v = u + at$$

(ii) Second equation: $s = ut + \frac{1}{2}at^2$

Displacement s= area under v–t graph

Area = rectangle + triangle:

$$s = ut + \frac{1}{2}(v-u)t$$

But $v - u = at$, so:

$$s = ut + \frac{1}{2}at^2$$

(iii) Third equation: $v^2 = u^2 + 2as$

Area under graph:

$$s = \frac{(u+v)}{2}t \Rightarrow t = \frac{2s}{u+v}$$

From $v = u + at$:

$$v - u = a\left(\frac{2s}{u+v}\right) \Rightarrow (v-u)(u+v) = 2as$$
$$v^2 - u^2 = 2as \Rightarrow v^2 = u^2 + 2as$$

Hence derived.

24. How centripetal force is provided? (3 marks)

Centripetal force is the force that keeps a body in circular motion, directed towards centre.

(i) Planet around the Sun

Provided by gravitational force of the Sun on the planet.

(ii) Moon around the Earth

Provided by gravitational force of Earth on the moon.

(iii) Electron around nucleus

Provided by electrostatic (Coulomb) force of attraction between electron and nucleus.

25. Prove loss of energy in inelastic collision (3 marks)

In an inelastic collision, bodies stick together and move with common velocity.

Let masses m_1, m_2, velocities u_1, u_2

After collision common velocity v

By conservation of momentum:

$$\boldsymbol{m_1u_1 + m_2u_2 = (m_1 + m_2)v \Rightarrow v = \frac{m_1u_1 + m_2u_2}{m_1 + m_2}}$$

Initial kinetic energy:

$$\boldsymbol{K_i = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2}$$

Final kinetic energy:

$$K_f = \frac{1}{2}(m_1 + m_2)v^2$$

Since $v$is a weighted average, we always get:

$$K_f < K_i$$

So loss of kinetic energy:

$$\Delta K = K_i - K_f > 0$$

Hence, there is always loss of energy in inelastic collision (it converts into heat, sound, deformation etc.)

26. Rotating cylinder: KE and angular momentum (3 marks)

Given:

$m = 20kg, r = 0.25m, \omega = 100rad/s$

Moment of inertia of solid cylinder:

$$I = \frac{1}{2}mr^2 = \frac{1}{2}(20)(0.25)^2 = 10(0.0625) = 0.625\ kgm^2$$

(i) Rotational kinetic energy

$$K = \frac{1}{2}I\omega^2 = \frac{1}{2}(0.625)(100)^2 = 0.3125 \times 10000 = 3125J$$

$$\boxed{K = 3125J}$$

(ii) Angular momentum

$$L = I\omega = 0.625 \times 100 = 62.5\ kgm^2/s$$

$$\boxed{L = 62.5\ kgm^2/s}$$

27. Stress–strain curve + terms (3 marks)

(Write any 4–5 terms properly, it becomes full marks.)

Stress–strain curve (for ductile metal wire like steel)

- In the beginning, stress ∝ strain (straight line region)
- After elastic limit, curve bends
- Material yields and finally breaks.

Important terms:

Elastic limit: Maximum stress up to which body returns completely to original shape after load is removed.

Yield point: Point beyond which strain increases rapidly without much increase in stress (wire elongates a lot).

Breaking point: Point where wire fractures.

Permanent set: Permanent deformation left in wire after removing load beyond elastic limit.

Elastic hysteresis: When loading/unloading curves differ; some energy is lost as heat in one cycle.

Elastic strength: Maximum stress a material can withstand without breaking.

OR (Alternative) Bernoulli's Principle (3 marks)

Statement: In a streamline flow of a non-viscous incompressible fluid, the sum of pressure energy, kinetic energy and potential energy per unit volume remains constant.

$$P + \frac{1}{2}\rho v^2 + \rho g h = constant$$

Meaning: If speed increases, pressure decreases and vice versa (at same height).

28. SHM or periodic but not SHM (3 marks)

(a) Rotation of Earth about its axis
Periodic but NOT SHM
Reason: It is periodic, but not oscillation about mean position with restoring force.

(b) Oscillating mercury column in U-tube
Nearly SHM
Reason: Restoring force is proportional to displacement for small oscillations.

(c) Ball bearing in smooth curved bowl (released slightly above lowest point)
Nearly SHM
Reason: For small displacement near the mean position, restoring force ∝ displacement, so motion becomes SHM.

SECTION-D (Case Study Based Questions)

29.
Given:
Initial velocity $u = 0$(starts from rest)
Acceleration $a = 1\ m/s^2$
Time $t = 5\ s$
(i) Velocity after 5 s

$$v = u + at = 0 + (1)(5) = 5\ m/s$$

Ans: $\boxed{5\ m/s}$
(ii) Distance covered in 5 s

$$s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}(1)(5^2) = \frac{1}{2}(25) = 12.5\ m$$

Ans: $\boxed{12.5\ m}$
(iii) Acceleration at $t = 5s$
Since acceleration is uniform,

$$a = 1\ m/s^2$$

Ans: $\boxed{1\ m/s^2}$
(iv) Type of motion
Acceleration is constant ⇒ motion is uniformly accelerated motion (rectilinear).
Ans: $\boxed{\text{Uniformly accelerated motion}}$

OR (iv) Distance covered in next 5 seconds (from 5s to 10s)
Distance in first 10 s:

$$s_{10} = \frac{1}{2}a(10)^2 = \frac{1}{2}(1)(100) = 50m$$

Distance in first 5 s:

$$s_5 = 12.5m$$

Distance in next 5 s:

$$s = s_{10} - s_5 = 50 - 12.5 = 37.5m$$

Ans: $\boxed{37.5\ m}$

30. Carnot Engine Case Study (Answer any four) (1 mark each)

(i) In a Carnot cycle, working medium rejects heat at a ------------- temperature.
Heat is rejected to sink at lower temperature.
Correct option: (b) Lower

(ii) Which of the following is NOT a state variable?
Work is a path function, not a state variable.
Correct option: (a) Work

(iii) Efficiency of reversible heat engine is
Carnot efficiency:

$$\eta = 1 - \frac{T_2}{T_1}$$

Correct option: (d) $1 - \left(\frac{T_2}{T_1}\right)$

(iv) If temperature of the source is increased, efficiency will
Since $\eta = 1 - \frac{T_2}{T_1}$, increasing T_1 increases efficiency.
Correct option: (b) increase

OR (iv) Over complete Carnot cycle, entropy
In reversible Carnot cycle, total entropy change = 0.
Correct option: (c) constant

SECTION-E

31. (a) Acceleration due to gravity (5 marks)

Meaning

Acceleration due to gravity (g) is the acceleration produced in a body when it falls freely under the gravitational pull of Earth.

Derivation of expression for g

Force on a mass m at Earth's surface:

$$F = \frac{GMm}{R^2}$$

But gravitational force also equals:

$$F = mg$$

Equating:

$$mg = \frac{GMm}{R^2}$$

Cancel m:

$$g = \frac{GM}{R^2}$$

Expression:

$$\boxed{g = \frac{GM}{R^2}}$$

Where
G= gravitational constant,
M= mass of Earth,
R= radius of Earth.

Finding mass of Earth using G

From:

$$g = \frac{GM}{R^2} \Rightarrow M = \frac{gR^2}{G}$$

Hence mass of Earth:

$$\boxed{M = \frac{gR^2}{G}}$$

Finding density of Earth

Density:

$$\rho = \frac{M}{V}$$

Volume of Earth:

$$V = \frac{4}{3}\pi R^3$$

$$\rho = \frac{M}{\frac{4}{3}\pi R^3}$$

Substitute $M = \frac{gR^2}{G}$:

$$\rho = \frac{\frac{gR^2}{G}}{\frac{4}{3}\pi R^3} = \frac{3g}{4\pi GR}$$

Density:

$$\boxed{\rho = \frac{3g}{4\pi GR}}$$

OR: 31(b) Escape speed (5 marks)

Meaning

Escape speed is the minimum speed with which a body must be projected from Earth's surface so that it can escape Earth's gravitational field and never return.

Derivation

To escape, total energy at Earth surface should be ≥ 0.
At surface:
Kinetic energy:

$$K = \frac{1}{2}mv_e^2$$

Potential energy:

$$U = -\frac{GMm}{R}$$

For escape, final energy at infinity = 0:

$$\frac{1}{2}mv_e^2 - \frac{GMm}{R} = 0$$

$$\frac{1}{2}mv_e^2 = \frac{GMm}{R} \Rightarrow v_e^2 = \frac{2GM}{R}$$

$$v_e = \sqrt{\frac{2GM}{R}}$$

But $g = \frac{GM}{R^2} \Rightarrow GM = gR^2$

$$v_e = \sqrt{2gR}$$

Escape speed:

$$\boxed{v_e = \sqrt{2gR}}$$

Why Moon has no atmosphere

Moon's gravity is very small ⇒ escape speed is small (~2.4 km/s).

Gas molecules gain enough speed due to temperature and escape easily, so moon cannot retain atmosphere.

Hence no atmosphere on moon.

32. (i) Bernoulli's Theorem + (ii) Venturimeter numerical (5 marks)

(i) Bernoulli's Theorem (Statement + Proof idea)

Statement:

For an ideal fluid (non-viscous, incompressible) in streamline flow, total energy per unit volume remains constant:

$$\boxed{\boldsymbol{P + \frac{1}{2}\rho v^2 + \rho g h = constant}}$$

Where

P=pressure energy/volume

$\frac{1}{2}\rho v^2$=kinetic energy/volume

$\rho g h$=potential energy/volume.

Proof

Consider flow through a tube with two points 1 and 2.

Work done by pressure force:

$$W = P_1V - P_2V$$

Increase in kinetic energy:

$$\Delta K = \frac{1}{2}\rho V(v_2^2 - v_1^2)$$

Change in potential energy:

$$\Delta U = \rho V g(h_2 - h_1)$$

By energy conservation:

$$P_1V - P_2V = \frac{1}{2}\rho V(v_2^2 - v_1^2) + \rho V g(h_2 - h_1)$$

Divide by V:

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

Hence:

$$\boxed{P + \frac{1}{2}\rho v^2 + \rho g h = constant}$$

(ii) Venturi meter numerical
Given:
Area at wide part: $A = 8\,mm^2$
Area at narrow: $a = 4\,mm^2$
Pressure drop:

$$\Delta P = P_1 - P_2 = 24\,Pa$$

Assume same height.
Step 1: Continuity equation

$$Av_1 = av_2 \Rightarrow v_2 = \frac{A}{a}v_1 = \frac{8}{4}v_1 = 2v_1$$

Step 2: Apply Bernoulli (same height)

$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$$

$$P_1 - P_2 = \frac{1}{2}\rho(v_2^2 - v_1^2)$$

$$24 = \frac{1}{2}\rho((2v_1)^2 - v_1^2) = \frac{1}{2}\rho(4v_1^2 - v_1^2) = \frac{1}{2}\rho(3v_1^2)$$

$$24 = \frac{3}{2}\rho v_1^2 \Rightarrow v_1^2 = \frac{24 \times 2}{3\rho} = \frac{16}{\rho}$$

For blood, $\rho \approx 1000\,kg/m^3$

$$v_1 = \sqrt{\frac{16}{1000}} = \sqrt{0.016} = 0.126\,m/s$$

Speed of blood in artery:

$$\boxed{v_1 \approx 0.13\,m/s}$$

OR: 32 (i) Modes of heat transfer + (ii) density change (5 marks)

(i) Modes of heat transfer

1. Conduction

Heat transfer through a solid without actual motion of particles.
Example: heating one end of an iron rod.

2. Convection

Heat transfer in fluids by actual motion of molecules.
Example: water circulation in boiling water.

3. Radiation

Heat transfer through electromagnetic waves (no medium required).
Example: heat from Sun reaching Earth.

(ii) fractional change in density of glycerine

Given:

$$\beta = 49 \times 10^{-5} K^{-1}$$
$$\Delta T = 30^{\circ}C$$

For liquids:

$$\frac{\Delta V}{V} = \beta \Delta T$$

Density $\rho = \frac{m}{V}$
So fractional change in density:

$$\frac{\Delta\rho}{\rho} = -\frac{\Delta V}{V}$$

$$\frac{\Delta\rho}{\rho} = -\beta\Delta T = -(49 \times 10^{-5})(30)$$

$$= -1470 \times 10^{-5} = -0.0147$$

$$\boxed{\frac{\boldsymbol{\Delta\rho}}{\boldsymbol{\rho}} = \mathbf{-0.0147}}$$

(meaning density decreases by 1.47%)

33. (i) Newton's formula + Laplace correction (5 marks)

(i) Newton's formula (velocity of sound in air)
Newton assumed sound propagation is isothermal process.
Speed of sound:

$$v = \sqrt{\frac{P}{\rho}}$$

Where
P=pressure of air
ρ=density of air.
But experimentally, this gives smaller value than actual.

Laplace correction
Laplace stated that compression & rarefaction in sound are adiabatic, not isothermal.
For adiabatic change:

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

Where $\gamma = \frac{C_p}{C_v}$
Correct formula:

$$\boxed{v = \sqrt{\frac{\gamma P}{\rho}}}$$

This matches experimental speed of sound.
(ii) Numerical (wavelength)
Given: speed $v = 900\, m/s$
Number of waves $N = 3000$in $t = 2\, min = 120s$
Frequency:

$$f = \frac{N}{t} = \frac{3000}{120} = 25Hz$$

Wavelength:

$$\lambda = \frac{v}{f} = \frac{900}{25} = 36m$$

$\boxed{\lambda = 36\, m}$

OR: SHM question

Given:

$$x = 5\cos(2\pi t + \pi/4)$$

So:

Amplitude $A = 5m$

Angular frequency $\omega = 2\pi\, rad/s$

Phase $\phi = \omega t + \pi/4$

At $t = 1.5s$:

$$\phi = 2\pi(1.5) + \pi/4 = 3\pi + \pi/4 = \frac{13\pi}{4}$$

Now:

$$\cos\left(\frac{13\pi}{4}\right) = \cos\left(3\pi + \frac{\pi}{4}\right) = -\cos\frac{\pi}{4} = -\frac{\sqrt{2}}{2}$$

$$\sin\left(\frac{13\pi}{4}\right) = -\sin\frac{\pi}{4} = -\frac{\sqrt{2}}{2}$$

(a) Displacement

$$x = 5\cos\phi = 5\left(-\frac{\sqrt{2}}{2}\right) = -\frac{5\sqrt{2}}{2} \approx -3.54m$$

$\boxed{x = -3.54m}$

(b) Speed (velocity)

$$v = \frac{dx}{dt} = -A\omega\sin\phi = -5(2\pi)\left(-\frac{\sqrt{2}}{2}\right) = 5\pi\sqrt{2} \approx 22.2\, m/s$$

$\boxed{v \approx 22.2\, m/s}$

(c) Acceleration

$$a = \frac{d^2x}{dt^2} = -\omega^2 x = -(2\pi)^2(-3.54) \approx 139.6\, m/s^2$$

$\boxed{a \approx +140\, m/s^2}$
