FIRST YEAR- FIRST TERMINAL EVALUATION 2019-2020

PART.III

PHYSICS

Maximum: 60 Scores

Cool – off time:15 minutes. **Time:2 hours**

Questions 1 to 5 carry one score each. Answer any **FOUR** questions.

1. The working of telescopes and microscopes, colours in thin films etc are explained in 1
a. Thermodynamics b. Optics c. Electronics d.Mechanics.

Ans.b. Optics

2. Average distance of the sun from the earth is called 1
a. Fermi b. Angstrom c. Astronomical unit. d. Light year.

Ans. c. Astronomical unit.

3. Draw position – time graph of a stationary object. 1

4. An object is projected with a velocity 'v' at an angle θ with the horizontal. What is the velocity of the object at the highest point of its path. 1

Ans. vCosθ

5. "There is cause effect relation in Newton's third law" State whether statement is TRUE or FALSE. 1

Ans. This statement is false. There is **<u>no</u>** cause effect relation in Newton's third law.

Questions 6 to 13 carry two score each. Answer any **SEVEN** questions.

6. Fill in the blanks in the table. 2

....	Base unit	Symbol
Length	....	....
Electric current	....	A
....	....	mol
....	Candela	....

Ans.

Base quantity	Base unit	Symbol
Length	**metre**	**m**
Electric current	**ampere**	A
Amount of substance	mole	mol
Luminous Intensity	Candela	**cd**

7. The temperature of two bodies measured by a thermometer are $t_1 = 20°C \pm 0.5°C$ and $t_2 = 50°C \pm 0.3°C$. Calculate the temperature difference and error. 2

Ans. Temperature difference, $t = 50 - 20 = 30°C$
Error in the calculation of difference in temperature, $\Delta t = \Delta t_1 + \Delta t_2 = 0.5 + 0.3 = 0.8$

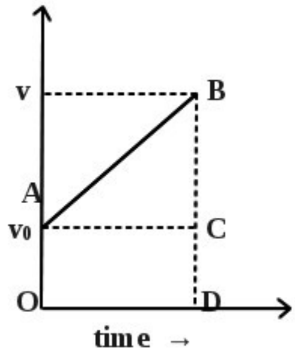
8. Using velocity – time graph derive relation, $v^2 = v_0^2 + 2ax$ 2

Ans. Velocity – time graph of a uniform accelerated motion is as shown. Here v_0 is the initial velocity and v be the velocity after time t. We know that displacement is equal to area below the velocity- time graph.
Therefore, displacement,

x = Area of the trapezium ABCDOA

$= \frac{1}{2} h(a+b) = \frac{1}{2}OD(DB+OA) = \frac{1}{2} t(v+v_0)$ ..... (1)

But we have $a = (v-v_0)/t$
Or $t = (v-v_0)/a$
Substitute 't' in the equation (1),
$x = \frac{1}{2}[(v-v_0)/a](v+v_0) = 1/2a[v^2 - v_0^2]$
Or $v^2 - v_0^2 = 2ax$

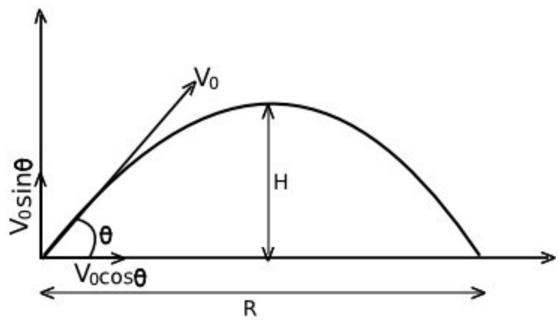


9. A car moving along a straight highway with speed of 35 m/s is brought to stop within a distance of 200m. How long does it take for the car to stop? 2

Ans. u = 35 m/s   s = 200 m,   v = 0   t = ?
From the equation $v^2 = u^2 + 2as$ $0 = 35x35 + 2xax200$
$400a = -35x35$ Or $a = -35x35/400\ m/s^2$
From equation $v = u + at$ $0 = 35 + -35x35/400\ x\ t$
or $t = 35x400/35x35 = 400/35 = 11.43$ s

10. Derive an expression for the maximum height attained by the projectile. 2

Ans. Consider a projectile projected with initial velocity v_0 making an angle θ with the horizontal as in figure.

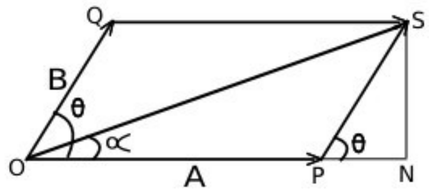


The velocity v_0 can be resolved into two components $v_0 \cos\theta$ along horizontal direction and $v_0\sin\theta$ along vertical direction.
Let H be the maximum height attained.
Initial vertical velocity, u $= v_0\sin\theta$
Final vertical velocity, v= 0
Acceleration a $= -g$
Vertical displacement x = H
Use the equation, $v^2 = u^2 + 2as$
$0 = (v_0\sin\theta)^2 + 2x\text{-}gxH$
Or $2gH = v_0^2\sin^2\theta$
Or $H = v_0^2\sin^2\theta/2g$

11 Find the magnitudes of the resultant of two vectors A and B in terms of their magnitudes and angle θ between them. 2

Ans.

Let OP&OQ represent two vectors A & B originating from the same origin O.



Let θ be the angle between the vectors. Construct a parallelogram with vectors A & B as sides and draw diagonal OS. According to Parallelogram method of addition, OS will be the sum of vectors A&B.

Draw normal SN to OP.

In right angled triangle ONS, $OS^2 = ON^2+SN^2$ …….. (1)

But ON = OP + PN and from triangle PSN, Cosθ =PN/PS Or PN = PSCosθ = Bcosθ

Similarly SN= Bsinθ

Eqn. (1) becomes $OS^2 = (A+BCos\theta)^2+(B\sin\theta)^2$

$= A^2+B^2Cos^2\theta+2ABCos\theta + B^2Sin^2\theta$

$= A^2+B^2(Sin^2\theta + Cos^2\theta)+2A.BCos\theta = A^2+B^2+2ABCos\theta$

Magnitude of the resultant vector $R = \sqrt{(A^2+B^2+2ABCos\theta)}$

12 A body of mass 5 kg is acted upon by two perpendicular forces 8N and 6N. Give the magnitude and direction of the acceleration of the body. 2

Ans. Net force acting on the body = $\sqrt{(8^2+6^2+ 2\times8\times4\times\cos90)} = \sqrt{(64+36+0)}$ = 10N

Let α be the angle between 8N & resultant force 10N.

Then $\tan\alpha = B \sin\theta/(A+B\cos\theta) = 6\times\sin90/(8+6\times\cos90) = 6\times1/(8+0) = 3/ 4 = 0.7500$

$\alpha = 36.87^0$.

Acceleration a = F/m = 10/5 = 2 m/s

Its direction will be 36.87^0 deviated from 8N towards 6N force.

13 State the law of conservation of momentum and prove it based on Newton's second law of motion. 2

Ans. Consider a system of n particles of masses $m_1, m_2,\ldots\ldots m_n$ moving with velocities $v_1, v_2\ldots\ldots v_n$.

The total linear momentum $P = m_1v_1 + m_2v_2 +\ldots\ldots\ldots\ldots+ m_nv_n$.

According to second Law, F_{ext} =dp/dt

If $F_{ext} = 0$ dp/dt = 0 Or p = a constant.

That is, $m_1v_1 + m_2v_2 +\ldots\ldots\ldots\ldots+ m_nv_n$ = a constant.

Thus if there is no external force acts on a system, the total linear momentum of the system is conserved.

Questions 14 to 19 carry three score each. Answer any **FIVE** questions.

14. Centripetal force (F) of an object moving along the circumference of a circle depends on its mass (m), velocity (v) and radius (r) of the circle. Drive an expression for the centripetal force using the method of dimensions. 3

Ans. Let $F = m^av^br^c$ .... (1)

Take dimensions on both sides,

$M^1L^1T^{-2} = M^a . (L^1T^{-1})^b. L^c = M^a .L^bT^{-b}. L^c$

$M^1L^1T^{-2} = M^a L^{b+c}T^{-b}$.

Equate dimensions on both sides, then a = 1 b+c = 1 and -b = -2

That is, a = 1, b = 2 and c = 1 – b = 1 – 2 = -1

Substitute the values of a,b and c in eqn. (1)

$F = mv^2r^{-1} = mv^2/r$

15. A physical quantity P is related with four variables a,b, c and d as follows $P = a^2b^3/d\sqrt{c}$ 3

The percentage errors of measurement in a,b,c and d are 1%,3%,4% and 2% respectively. What is the percentage error in P?

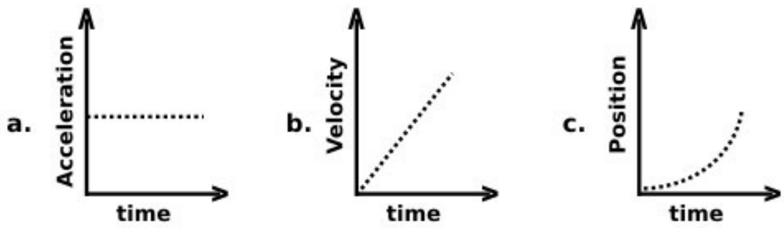
Ans. Percentage error in P = 2x% error in a + 3x% error in b + 1x% error in d + ½x% error in c
= 2x1 + 3x3 + 1x2 + ½x4 = 2+9+2+2 = 15%

16. A ball is thrown vertically upward with a velocity of 20 m/s from the top of a multi-storey building 25m high. How long will it be before the ball hits the ground? Take g = 10 ms^{-2}. 3

Ans. u = 20 m/s a = 10 ms^{-2} s = -25 m
We have $s = ut + \frac{1}{2}at^2$
$-25 = 20xt + \frac{1}{2}\, x\text{-}10xt^2$ Or $-5t^2 + 20t + 25 = 0$
Or $t^2 - 4t - 5 = 0$ t = 5 or -1
That is, the stone will hit the ground after 5 seconds.

17. Draw the graphs showing the following variations for free fall. 3
a. Acceleration with time. b. Velocity with time c. Distance with time.

Ans.



18. State Newton,s second law and derive an expression for force. 3

Ans. Second Law:The law states that the rate of change of linear momentum of a body is directly proportional to the external force applied on the body, and takes place always in the direction of the force applied.
Consider a body of mass 'm' moving with a velocity 'v'. The momentum is given by P = mv.
Let F be the force acting on the body in the direction of motion of the body. Let dp is a small change in linear momentum of the body in a small time dt.
Rate of change of linear momentum = dp/dt
According to second Law, F α dp/dt , F = k dp/dt , F = k d/dt(mv) = k m dv/dt
But dv/dt = a, acceleration. Then F = k ma. The unit of force, 'newton' is defined so that the constant of proportionality k = 1.
Then F = ma.

19. Impulsive force is a large force acting for a short time.
a. Define impulse and write its relationship with momentum. 1
b. A batsman hits back a ball straight in the direction of the bowler without changing ita initial speed of 12 ms^{-1}. If the mass of the ball is 0.15 kg, determine the impulse imparted to the ball. 2

Ans. a.i. Impulse is a measure of large force acting on a body for a very short interval of time.
Impulse = Ft.
ii. Impulse = change in momentum = mv – mu
b. here mass m = 0.15 kg, u = 12 ms^{-1}. v = - 12 ms^{-1}.
Impulse = mv – mu = m(v-u) = 0.15(-12 – 12) = -0.36 $kgms^{-1}$.

Questions 20 to 23 carry four score each. Answer any **THREE** questions.

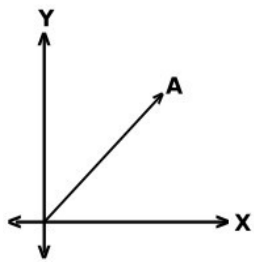
20. a. State the number of significant figures in the following mismeasurements. 2
i. 3067 ii. 0.0450 iii. 8.0901 iv. 40.00
b. The length, breadth and thickness of a rectangular sheet of metal are 4.23 m, 1.005 m, and 2.01 cm respectively. Calculate the volume of the sheet to correct significant figures. 2

Ans. a. i. 3067 → 4 ii. 0.0450 → 3 iii. 8.0901 → 5 iv. 40.00 → 4
b. Volume = 4.23x1.005x0.0201= 0.088448 m^3
It is to be rounded to 0.0884 m^3 by keeping only three significant figures.
(Because the least significant figures among the three measurements is three)

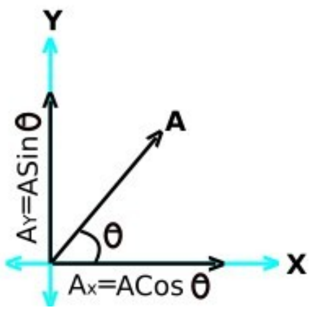
21. a. Define instantaneous velocity. 1
b. The position of an object moving along x – axis is given by $x = 8.5 + 2.5t^2$.
i. What is its velocity at t = 2.0 s 1
ii. What is the average velocity between t = 2.0s and t = 4.0 s 2

Ans. a. The velocity at an instant is called instantaneous velocity.
b.i. Velocity $v= d/dt(8.5 + 2.5t^2)$ = 2x2.5xt = 5t
Then velocity at t = 2.0 s, v_1 = 5x2 = 10 m/s
b.ii. Velocity at t = 4.0 s , v_2 = 5x4 = 20 m/s
Average velocity v_{av} = (10+20)/2 = 15 m/s

22. a. Figure shows a vector A in xy plane. Redraw the figure and draw and label its rectangular components. 2
b. Calculate the magnitude of the vector P = 3i + 4j + 12k 2



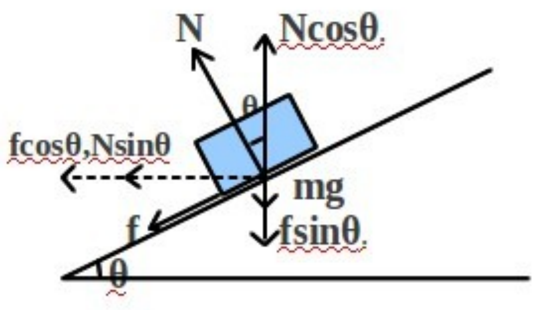
Ans.a.



b. Magnitude of vector P = $(\sqrt{(3^2+4^2+12^2)}$ $= \sqrt{169} = 13$

23 Derive an expression for the maximum safe speed of a car on a banked road. Get an expression for the optimum speed also. 4

Ans.a. i.Suppose a vehicle of mass 'm' moves along a banked road of radius of curvature R as shown.
Let θ be the angle of banking.
The normal reaction N is resolved into Ncosθ & Nsinθ and frictional force 'f' is resolved into f.sinθ & f.cosθ as in fig.
Equate the opposite forces.



Then N cosθ = mg + f sinθ …..(1)
And N sinθ + f cosθ = mv^2/R ……(2)
But maximum friction, $f = \mu_s N$
Substitute this in equations (1)&(2).
Then eqn(1)→ N cosθ = mg + μ_sNsinθ
→ N (cosθ – μ_s sinθ) = mg …...(3)
similarly eqn. (2) becomes N(sinθ+ $\mu_s$cosθ) =mv_m^2/R …….(4)
Dividing (4) by (3), (sinθ+$\mu_s$cosθ)/(cosθ –μ_s sinθ) = v_m^2/Rg
Or $v_m = \sqrt{\{Rg(\sin\theta+ \mu_s\cos\theta)/ (\cos\theta -\mu_s \sin\theta)\}}$
Divide the numerator and denominator of RHS of this equation with cosθ.
Then v_m = $\mathbf{\{Rg\ (\mu_s+ \tan\theta)/(1- \mu_s \tan\theta)\}^{1/2}}$ ………(5)

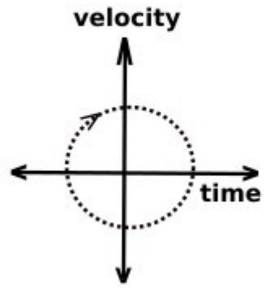
It is the maximum speed of a vehicle at a turning of radius of curvature R, than can take without skidding.
ii. Put μ_s =0, we get optimum speed $v_o = \sqrt{(Rg.\tan\theta)}$
At this speed frictional force is not needed at all.

Questions 24 to 27 carry five score each. Answer any **THREE** questions.

24. a."Velocity cannot be added with temperature". According to which basic principle in physics, this becomes true. 1
b. Check the dimensional consistency of the following equations. 2
i. $mc^2 = mgh$
[m – is mass, c the velocity of light, g the acceleration due to gravity and h the height of the object]
ii. $P = 4S/R^2$ [P the pressure which is force per unit area , S surface tension which is force per unit length and R the radius of a bubble] 2

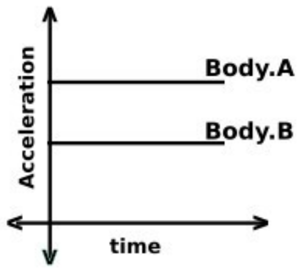
Ans.a. Homogeneity principle.
b.i. $[mc^2] = M(LT^{-1})^2 = ML^2T^{-2}$
$[mgh] = M(LT^{-2}).L = ML^2T^{-2}$
Since the the dimensions of LHS and RHS are the same, this equation is dimensionally consistent.
b.ii. $[LHS] = [P] = MLT^{-2}/L^2 = ML^{-1}T^{-2}$.
$[RHS] = (MLT^{-2}/L)/(L^2) = ML^{-2}T^{-2}$.
Since the dimensions of LHS and RHS are not the same. So the equation is dimensionally inconsistent.

25. a.Why the graph shown below cannot represent one dimensional motion of a particle? 1

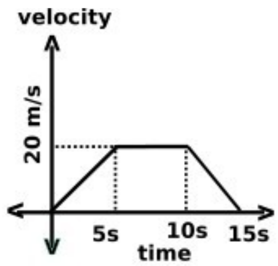


2

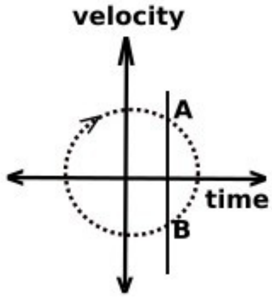
b. The acceleration – time graph of two bodies A and B are shown. Draw their velocity – time graph and mark the bodies A and B



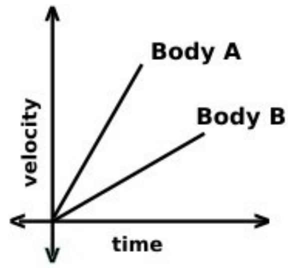
c. The velocity – time graph of an object is shown below. Calculate the displacement of the body from 0 to 15 seconds. 2



Ans. a. In this graph, line perpendicular to X -axis (time axis) intersects the graph at two points (A & B) as shown. It means that the object will have two velocities at the same time. It is impossible. So this graph cannot represent one dimensional motion of a particle.

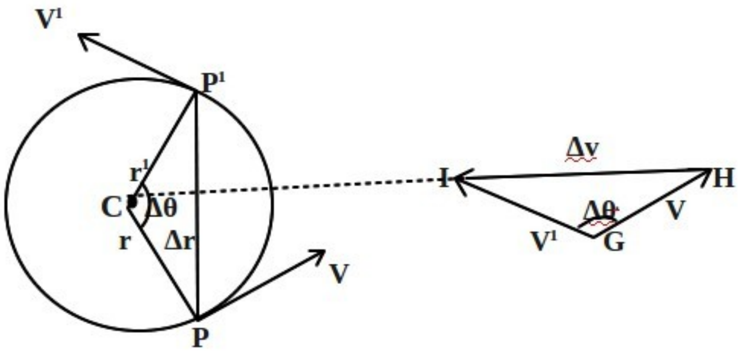


b. It is noted that the body A has greater acceleration than that of body B. Slope of velocity time graph is numerically equal to acceleration. So slope of velocity – time graph of body A will have greater slope than that of B.
c. Displacement = Area of the trapezium
= ½h(a+b) = ½ x 20x(15+5) =200 m



26. a. Define uniform circular motion. 1
b." Uniform circular motion is an accelerated motion" State whether this statement is TRUE or FALSE. 1
c.Derive an expression for centripetal acceleration and show geometrically that this acceleration is directed towards centre of the circle. 3

Ans.a. If an object follows a circular path with constant speed, the motion is said to be uniform circular motion.
b. This statement is true. Because the direction of velocity of a particle in uniform circular motion is being changed continuously.
c. Consider a uniform circular motion of a particle along a circular path of radius R with speed v.
Let r & r' be the position vectors and v & v' be the velocities of the particle when it is at P & P' as shown in the figure.
Let Δt be the time to travel the particle from P to P'.
The velocity at any instant is tangential to the path as shown. To find the change in velocity, take the velocity vectors v & v' to the external point G and construct a triangle with sides v, v' & the change in velocity Δv.

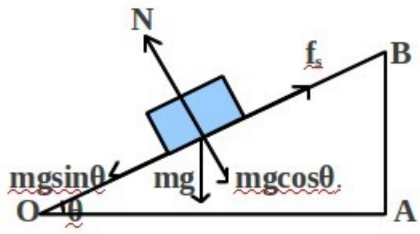


We have average acceleration , a = Δv/Δt.
Since v is perpendicular to r and v' is perpendicular to r', Δv is perpendicular Δr.
As the direction of acceleration is the direction in which velocity changes, 'a' will be perpendicular to Δr and is directing towards the centre of the circular path.

Since the velocity vectors v& v' are always perpendicular to position vectors r&r', angle Δθ between them are also same. So the triangles CPP' & GHI are similar triangles. And hence the sides ratio are equal.
Then Δv/Δr = v/R Or Δv = v.Δr/R
By substituting this in equation for acceleration, a = Δv/Δt
Then, a = (v/R).(Δr/Δt) when Δt → 0, Δr/Δt = dr/dt= v
So a = (v/R).v = v^2/R. Therefore, centripetal acceleration $\mathbf{a_c = v^2/R}$.
But we have v = Rω
Then $\mathbf{a_c = (R\omega)^2/R = R\omega^2}$

27. a.State the laws of static friction. 2
b. A mass of m rests on a horizontal plane. The plane is gradually inclined until at an angle θ with the horizontal, the mass just begins to slide. Show that the coefficient of static friction between the block and the surface is equal to tanθ 3

Ans.a.i.Limiting value of static friction $(f_s)_{max}$ depend on the nature of the surfaces in contact.
ii. Limiting value of static friction $(f_s)_{max}$ is independent of area of surfaces in contact.
Iii. Limiting static friction proportional to normal reaction. ie, $(f_s)_{max} = \mu_s N$.
Where μ_s is coefficient of static friction.
iv. Static friction acts tangential to the surfaces in contact.
b. The forces acting on the block of mass m when just begins to slide are
1. the weight mg acting vertically downwards
2. the normal reaction N acting by the plane on the block
3. limiting friction $(f_s)_{max.}$ opposite to the direction of sliding..



The weight mg can be resolved into two components mgcosθ and mgsinθ as shown.
Equate the opposite forces.
Then $mg\sin\theta = (f_s)_{max} = \mu_s N$ ……(1)
and $mg\cos\theta = N$ ……(2)
(2)/(1), $\mu_s = \tan\theta$
Hence the proof.