BK BIRLA CENTRE FOR EDUCATION

SARALA BIRLA GROUP OF SCHOOLS
SENIOR SECONDARY| CO-ED DAY CUM BOYS' RESIDENTIAL SCHOOL

MID-TERM EXAMINATION 2024-25

PHYSICS (042)

Class : XI | Duration: **3 Hrs**
Date : 21/09/2024 | Max. Marks: **70**

MARKING SCHEME

1. (b) Pascal 1
2. (c) Solid angle 1
3. (a) 3 1
4. (d) remains constant 1
5. (b) $2\pi R$, 0 1
6. (c) has an inward radial acceleration 1
7. (c) There should be no air-resistance 1
8. (a) both parts will have numerically equal momentum 1
9. (c) The combination of forces acting on it balances each other. 1
10. (a) Lighter body 1
11. (c) Zero 1
12. (b) KE= $1/2\ I\omega^2$ 1
13. (d) If Assertion is false bur Reason is true. 1
14. (a) If both Assertion and Reason are true and Reason is correct explanation of Assertion. 1
15. (c) If Assertion is true but Reason is false. 1
16. (d) If Assertion is false bur Reason is true. 1
17. The units which can neither be derived from one another nor can they be further resolved into other units are known as fundamental units. Some of the fundamental units are metre (length), kilogram (mass), second (time), Kelvin (temperature), ampere (current), etc. (1+1)
18. The rate of change of tangential velocity is called as the centripetal acceleration.
    $F=mv^2/r$ ½
    centripetal acceleration is given by,

    $a=F/m = mv^2/r\ m$ ½
    $\therefore a_c=v^2/r$ ½

    Its direction is always towards the centre of the circle. ½

    Or

    Given,

$u=40m/s$, $H=25m$, $g=10m/s^2$

The maximum height in projectile motion,

$H=u^2\sin^2\theta/2g=25m$ 1

$\sin^2\theta=25\times 2g/u^2$

$\sin^2\theta=25\times 2\times 10/(40\times 40)$

Maximum Horizontal range in projectile motion,

$R=u^2\sin 2\theta/g$ ½

$R=40\times 40\sin(2\times 33.98)/10$

$R=148.32m$ ½

19. Newton's First Law of Motion explains how inertia affects moving and non-moving objects. Newton's first law states that an object will remain at rest or move at a constant speed in a straight line unless it is acted on by an unbalanced force. Inertia comes from mass. Objects with more mass have more inertia. 1
According to Newton's first law, an unbalanced force is needed to change the speed or direction of the spacecraft. This force could be supplied by the spacecraft's engines. Because of inertia, an object at rest will remain at rest until something causes it to move. Likewise, a moving object continues to move at the same speed and in the same direction unless something acts on it to change its speed or direction. 1

20. Consider an object in rectilinear motion under constant acceleration a
According to the third equation of motion,
$v^2-u^2=2as$ -------- (1) ½
Multiplying equation (1) by m^2 on both the sides, we get,
$1/2mv^2-1/2mu^2=mas$ ½
We know,
$F = ma$
Hence
$1/2mv^2-1/2mu^2=Fs$
The distance traversed will be denoted by "d"
$1/2mv^2-1/2mu^2=Fd$- ------- (2) ½
Hence,
Equation (2) is the basis on which definitions of work and kinetic energy are obtained.
The LHS of equation (2) is denoted by "K".
The RHS of equation (2) is the product of distance travelled and the force component acting on it and this quantity is called "work"
Hence, equation (2) can also be written as,
$K_f-K_i=W$, which is also known as the quantitative statement of the work-energy theorem. This statement is applicable to a constant force and a variable force as well. ½

21.

Let

m_1=100g, m_2=150g, m_3=200ga=0.5m=50cm

Center of mass coordinates:-

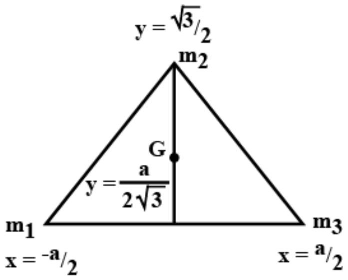
x= [(−a/2) × m_1+0×m_2+ (a/2) × m_3]/ ($m_1+m_2+m_3$) = (m_3−m_1) a/ 2($m_1+m_2+m_3$) = (200−100)50/ (2×450) =50/9cm 1

y= (0×m_1+√3/2×a×m2+0×m3)/ ($m_1+m_2+m_3$) =√3/2×a×m_2/ ($m_1+m_2+m_3$) =25√3cm

'y' coordinates of the centroid of the triangle

=1√3×√32×a=25/√3cm 1

∴ the center mass is 50/9cm.



22.

A=2 × (L×B+B×T+T×L) ½

∴A=2× (4.234×1.005+1.005×0.0201+0.0201×4.234)

∴A=2× (4.2552+0.0202+0.0851)

∴A=8.721m^2 to correct significant digits 1

V=L×B×T ½

∴V=4.234×1.005×0.0201

∴V=0.0855m^3 to correct significant digits 1

Or

The dependence of time period T on the quantities l, g and m as a product may be written as:

T = k l^x g^y m^z. 1

By considering dimensions on both sides, we have $[L^0M^0T] = [L]^x [L T^{-2}]^y [M]^z$

= $L^{x+y} T^{-2y} M^z$ 1

on equating the dimensions on both sides, we have x + y = 0; –2y = 1; and z = 0 So that

Then, T = k $l^{½} g^{-½}$ 1

23. x= 76m 1

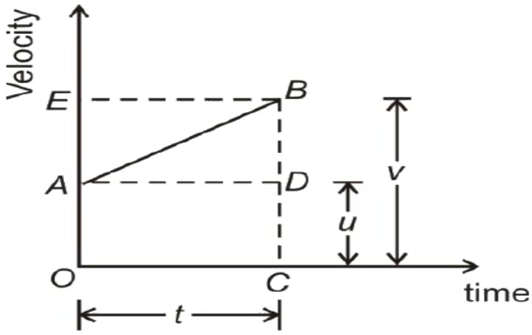
v= dx/dt ½

= 64 m/s; ½

a = dv/dt ½

=28 m/s^2 ½

24.



Initial velocity = OA = u = CD

Final velocity = OE = v = CB

BC = BD + DC

V = BD + u

BD = v – u,   OC = AD = t

Slope of (AB) or velocity time graph is acceleration

$$a = \frac{BD}{AD} = \frac{v-u}{t}$$

at = v – u or v = u + at   1

$$s = \left(\frac{v+u}{2}\right) \times t \Rightarrow s = \left(\frac{u+at+u}{2}\right) \times t$$

$$\Rightarrow s = \frac{2u+at}{2} \times t \Rightarrow s = \left(\frac{2u}{2} + \frac{at}{2}\right) \times t$$

$$\Rightarrow s = \left(u + \frac{at}{2}\right)t = ut + \frac{1}{2}at^2$$

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

Displacement $s = \left(\frac{Final\ velocity + Initial\ velocity}{2}\right) \times t$

$$s = \left(\frac{v+u}{2}\right) \times t$$

From the first equation of motion; $v = u + at$

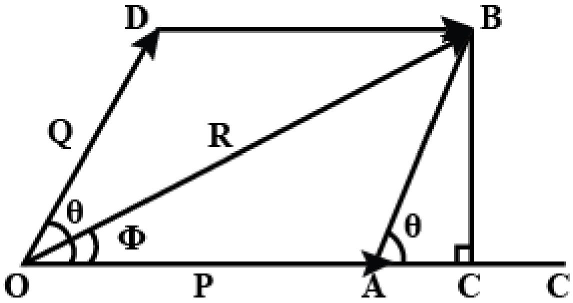
$$\Rightarrow t = \left(\frac{v-u}{a}\right)$$

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

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

1+1

25. Let P and Q be two vectors acting simultaneously at a point and represented both in magnitude & direction by two adjacent sides OA and OD of a parallelogram OABD as shown in figure. Let θ be the angle between P and Q and R be the resultant vectors. According to parallelogram law of vector addition, diagonal OB represents the resultant of P and Q.



1

So, R=P+Q

From triangle OCB

$OB^2=OC^2+BC^2 \quad = (OA+AC)^2+BC^2$ .....(1)

In ΔABC

Cos θ = AC/AB

AC=AB cos θ =OD cos θ=Q cos θ

Also

Cos θ =BC/AB

BC=AB sin θ =Q sin θ

Magnitude of Resultant substituting AC & BC in equation (1) we get

$R^2= (P+ Q \cos\theta)^2+ (Q \sin\theta)^2$

$\therefore R= \sqrt{(P^2+2PQ\cos\theta+Q^2)}$ 1

From Δ ABC

Tan ϕ=Q sin θ / (P+Q cos θ)

$\therefore \phi=\tan^{-1} (Q \sin\theta / (P+Q \cos\theta))$ 1

26. Newton's second law of motion states that the force exerted by a body is directly proportional to the rate of change of its momentum. For a body of mass 'm', the velocity changes from u to v in time t, when force 'F' is applied. 1

$F \propto$ Change in momentum /Time

$F \propto (mv-mu)/ t$

$F \propto m(v-u)/ t$ 1

$\Rightarrow F \propto ma \Rightarrow F = k\, ma \; (\because a=(v-u)/t)$ 1

27. An inelastic collision occurs when some amount of kinetic energy of a colliding object/system is lost. ½

 ½

From conservation of momentum

$m_1v_1 = (m_1+m_2)\, v_2 \rightarrow v_2 = m_1v_1/\,(m_1+m_2)$ 1

The ratio of kinetic energies before & after collision is

$KE_f /\, KE\ i = 1/2(m1+m2)/\,[m_1\, v_1^2/\,(m_1+m_2)]/\,(1/2m_1v_1^2 = m_1/\,(m_1+m_2)$

The fraction of kinetic energy lost is

$(KE_i - KE_f)/\, KE\ i = [1 - m_1/\,(m_1+m_2)]\, KE\ i/\, KE\ i = m_2/\,(m_1+m_2)$ 1

Hence energy always loss in inelastic collision.

28.

Given M=20kg, ω=100 rad/sec and R=0.25m

Kinetic energy (Rotation) = $(1/2)\, I\times\omega^2$ 1

$= (1/2)\,(MR^2/2) \times \omega 2$

$= (20)\,(0.25)^2/4\times (100)^2$

$=20\times 625/\,4=3125J$

=3.125KJ 1

L (angular momentum) = $I\,\omega = (MR^2/2) \times \omega$

$= (20\,(2.05)^2/2) \times 100 = 62.5Js.$ 1

29. (i) (b) First, the car B moves backward and then forward 1
(ii) (d) first, the car A moves forward and then backward 1
(iii) (c) First increases, then decreases and finally increases again 1
(iv) (a) 62.5 m due North of starting point 1
Or
(iv) (a) 25 m due North of starting point 1

30. (i) (b) 500J 1
(ii) (b) 10^4 J 1
(iii) (d) less than ½ Mv^2 1
(iv) (a) 1.4 S 1
Or
(iv) (d) 475J 1

31.

Let a body is projected with speed um/s inclined θ with horizontal line.

Then, vertical component of u, $u_y = u\cos\theta$

Horizontal component of $u_x = u \sin\theta$

Acceleration on horizontal, $a_x=0$

Acceleration on vertical, $a_y=-g$

Now, use formula

$X=u_x t$

$X=u\cos\theta.t$

$t=X/u\cos\theta$ -------------------------- (1) ½

Again, $y=u_y t+1/2 a_y t^2$

$y=u\sin\theta t-1/2gt^2$

From equation (1),

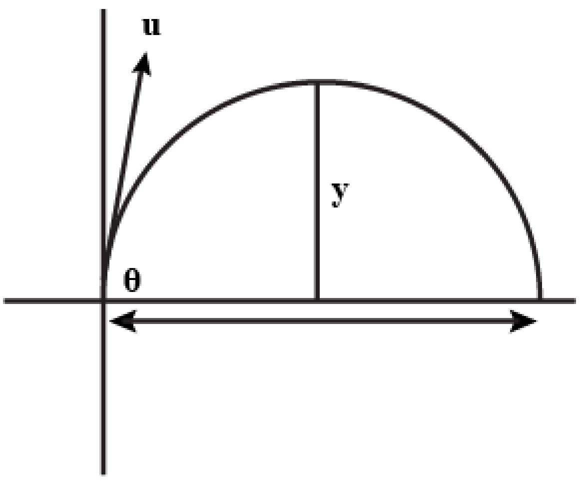
$y=u\sin\theta \times x/u\cos\theta-(1/2)\,g\times x^2/u^2\cos^2\theta$

$=\tan\theta\, x-(1/2)\,gx^2/u^2\cos^2\theta$

$y=\tan\theta.x-(1/2)\,g\,x^2/u^2\cos^2\theta$ ----------------(2) 1

This equation is similar to standard equation of parabola $y=ax^2+bx+c$ her, a, b and c are constant

So, a projectile motion is parabolic motion.



½

Time of Flight

It is the total time taken by the projectile when it is projected from a point and reaches the same horizontal plane or the time for which the projectile remains in the air above the horizontal plane.it is denoted by T.

$u_y = u\sin\theta$, $a_y=-g$, $t=T/2$ and $v_y=0$

since, $v_y=u_y+at$

$\therefore 0=u\sin\theta-gT/2$

$\Rightarrow T=2u\sin\theta/g$ ....(3) 1

Maximum height of a projectile

It is the maximum vertical height attained by the object above the point of projection during its

flight. It is denoted by H.
$u_y = u \sin\theta$, $a_y = -g$, $y = H$, $t = T/2$
Using the relation $y = u_y t + (1/2)\, a_y t^2$, we have
$H = (u \sin\theta)T2 + (1/2)\,(-g)(T/2)^2$
or $H = u^2 \sin^2\theta / 2g$ ....(4) 1
Horizontal-range
It is the horizontal distance covered by the object between its point of projection and the point of hitting the ground. It is denoted by R.
$\therefore R = u \cos\theta \times T = u\cos\theta \times 2u\sin\theta/g$
or $R = u^2(2\sin\theta\cos\theta)/g$
As $2\sin\theta\cos\theta = \sin 2\theta$, we have
$R = u2\sin 2\theta/g$ ....(6) 1

Or

Rate of change of tangential velocity is called as the centripetal acceleration.

$F = mv^2/r$ 1

Centripetal acceleration is given by,

a_c =F/~~m~~

$= mv^2/r\ m$

$\therefore a_c = v^2/r$ 1

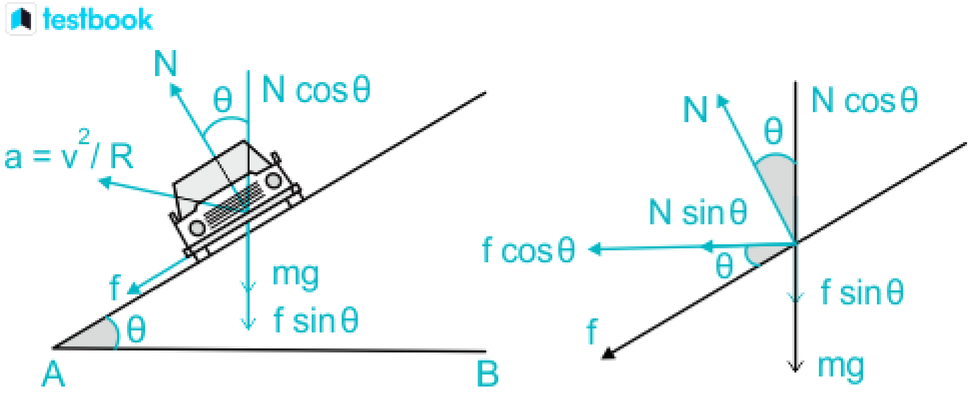
Length of the string, l = 80 cm = 0.8 m
Number of revolutions = 14
Time taken = 25 s
Frequency, v = Number of revolutions / Time taken = 14 / 25 Hz 1
Angular frequency, $\omega = 2\pi\nu$
$= 2 \times (22/7) \times (14/25) = 88 / 25$ rad s^{-1} 1
Centripetal acceleration, $a_c = \omega^2 r$
$= (88 / 25)^2 \times 0.8$
$= 9.91\ ms^{-2}$ 1
The direction of centripetal acceleration is always directed along the string, toward the centre, at all points.

32.
(a)Necessity of banking of road-

When a vehicle moves on a curved horizontal surface, friction force between wheels and road provides the necessary centripetal force. But friction force is enough sometimes like during rain as road is oily. Road should be made through then but it cause wear & tear of tyres. When centripetal force is less the vehicle skid. To eliminator this difficulty, roads are banked. When road is banked, the horizontal component of normal reaction provides necessary centripetal force required for circular motion. ½

Formula for Banking of Roads

Let a vehicle whose mass is ‘m’ is moving with speed ‘v’ on the banked road with a radius ‘r’. Let ϴ be the angle by which the road is elevated (angle of banking). The frictional force acting between the road and the vehicle is ‘f’.



1

Since we know that the total upward force is equal to the total downward force in a balanced system. In the image above, the total upward force is N cosϴ, where ‘N’ is the normal reaction force experienced by the vehicle and exerted by the road.

Total downward force is mg + f sinϴ, where ‘mg’ is the weight of the vehicle and ‘f sinϴ’ is the component of the frictional force ‘f’ between the road and the tyre acting along the vertical axis

Thus,

$N \cos \theta = mg + f \sin \theta$

$Mg = N \cos \theta - f \sin \theta$ …. (1)

Since centripetal force also acts on the vehicle, whose value can be stated as the sum of the component of the frictional force and the component of the normal reaction force along the same axis as the centripetal force,

$mv^2/r = N \sin\theta + f \cos \theta$ …. (2)

Dividing equation 2 by equation 1, we get

$v^2/rg = N \sin \theta + f \cos \theta /(N \cos \theta - f \sin \theta)$ …. (3)

Since, by definition, Frictional force is mathematically stated as

$f = \mu s\ N$

Thus, equation 3 can be written as,

$v^2/rg = N \sin \theta + \mu s\ N \cos\theta / (N\cos\theta - \mu s N \sin\theta)$ ½

Which can be further simplified as explained in the following lines:

$v^2/rg = N (\sin \theta + \mu s \cos \theta)/ N (\cos \theta - \mu s \sin \theta)$

$v^2/rg = (\sin\theta + \mu s\cos\theta)/(\cos\theta - \mu s \sin\theta)$

$v^2/rg = (\tan\theta + \mu s)/(1 - \mu s \tan\theta)$

$v = \{rg(\tan\theta + \mu s)/(1 - \mu s \tan\theta)\}^{½}$ 1

(b) The centripetal force needed to make the vehicle turn is

$Fc = m v^2 / r$ ½

m = mass of the car = 1000 kg

v = speed of the car = 15 m/s

r = radius of the turn = 50 m

Then

$Fc = 1000 \times 15^2 / 50 = 4500$ N ½

This force must be supplied by the friction between tires and road surface.

The frictional force is

$F_f = u\, m\, g$ ½

u = coefficient of static friction = 0.6

m = mass of the car = 1000 kg

g = gravity acceleration = 9.8 m/s^2

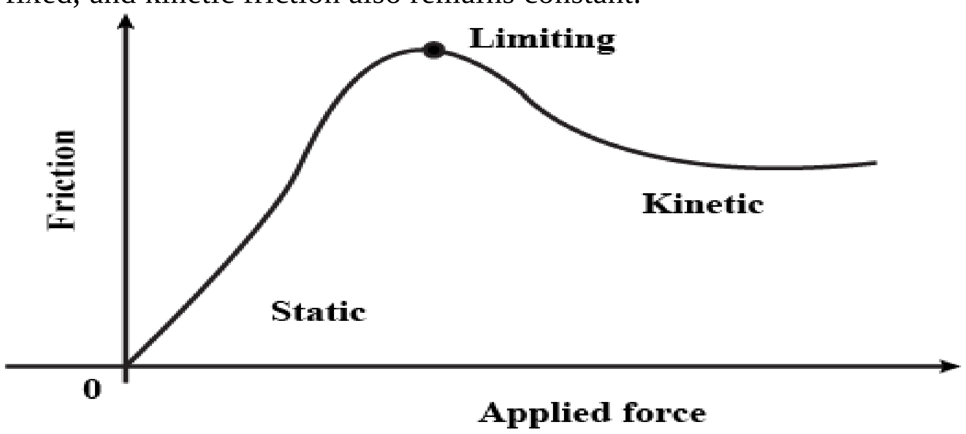
Then

Ff = 0.6 x 1000 x 9.8 = 5880 N ½

The frictional force is more than sufficient to keep the car turning, so the car will not skid.

Or

(a) The static friction is a friction that acts on a body at rest.
Limiting friction is the maximum value of static friction. It is the force that is required for the body to just start moving.
Kinetic friction is the frictional force that action a body which is in motion.
On increasing the applied force, static friction increase, until it reaches limiting friction which is fixed, and kinetic friction also remains constant. 1



1

(b) Friction can be reduced by: (Any Two) 1

Lubricating the surfaces.

Use of ball bearings (i.e. replacing sliding friction with rolling friction)

Streamlining the body.

(c) Friction is bound to occur between the rotating shaft and the part that supports the rotation. Bearings are used between these two components. The bearings serve to reduce friction and allow for smoother rotation. This cuts down on the amount of energy consumption. 2

33.

(a) Moment of inertia, in physics, is the measure of the volume of rotating inertia of the body, i.e., the resistance of the body showing its rotational speed relative to the axis altered by the use of torque. 1

SI Unit: Kgm^2 Dimension: $[ML^2T^0]$ 1

The moment of inertia depends on the following: Mass of the body. Size and shape of the body.1

(b) The radius of gyration is the distance from an axis of a body to the point in the body whose moment of inertia is equal to the moment of inertia of the entire body. The radius of gyration is equal to the square root of the ratio between the moment of inertia of the entire body and the mass of the whole system. 2

Or

(a) **Angular acceleration:** The rate of change of angular velocity is called angular acceleration.
$\therefore \alpha = dw / dt$ ½
Torque: The rate of change of angular momentum is called torque.
$\therefore \tau = dL/dt$ (or) $\tau = \bar{r} \times \bar{F}$ ½
Relation between α and τ :
Consider a rigid body of mass m rotating in a circular path of radius ‘r’ with angular velocity ’w’ about fixed axis by definition $\tau = dL/ dt$ ($\because L=Iw$)
$\Rightarrow \tau = d(Iw)/ dt$ ($\because$ where I = moment of inertia) 1

$\Rightarrow \tau = I dw/dt$

$\because dw/dt = \alpha$

$\Rightarrow \tau = I\alpha$ 1

(b) Scalar product, **a. b**= -6-4+15= 5 unit 1

Vector product **a** X **b** = 3**k**-9**j**-8**k**-12**i**-10**j**-5**i** = -17**i** -19**j** -5**k** 1

-------------------------END OF MS------------------------