BK BIRLA CENTRE FOR EDUCATION

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

MID-TERM EXAMINATION 2023-24

PHYSICS (042)

Class : XI — Duration: **3 Hrs**
Date : 09/10/2023 — **MARKING SCHEME** — Max. Marks: **70**

1. (a) Newton
2. (c) Solid angle
3. (a) 3
4. (c) velocity
5. (b) 2πR, 0
6. (c) has an inward radial acceleration
7. (b) constant velocity
8. (a) both parts will have numerically equal momentum
9. (c) the combination of forces acting on it balances each other
10. (b) Heavier body
11. (c) no work at all
12. (b) KE= 1/2 $I\omega^2$
13. (b)
14. (c)
15. (c)
16. (b)
17. The units of all other physical quantities which are derived from the fundamental units are called the derived units.Two examples are: Newton, Pascal…(Any Two) 1+1
18. The acceleration required for uniform circular motion. 1+1
    the acceleration is directed radially toward the centre of the circle. The centripetal acceleration ac has a magnitude equal to the square of the body's speed v along the curve divided by the distance r from the centre of the circle to the moving body; that is, $a_c = v^2/r$.

OR

We know the formula for calculating the maximum height the ball has attained-

$$H=u^2\sin^2\theta/2g$$

Where, is the speed of ball, θ is the angle of projection with horizontal and g is the acceleration due to gravity having value $9.8 m/s^2$

Therefore
$25 = (40)^2 \sin^2\theta / 2\times 9.8$

Rearranging the terms
$\sin^2\theta = 0.30625$ or $\sin\theta = 0.5534$

$\theta = \sin^{-1}(0.5534)$ or $\theta = 33.60^\circ$
Now applying formula for horizontal range,

$R = u^2 \sin 2\theta / g = (40)^2 \sin(2\times 33.60^\circ) 9.8 = 1600 \sin(67.2)/ 9.8 = 150.53$ m/s

19. If an object A exerts a force on object B, then object B must exert a force of equal magnitude and opposite direction back on object A. 1+1

    Explain

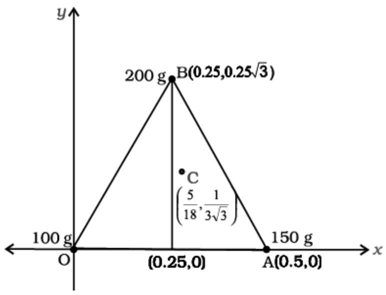
20. change in K.E of body $=1/2\, mV^2$ (½ +½+½+½)

    $V^2 = u^2 + 2as \Rightarrow V^2 = 2ax$

    $\Rightarrow \Delta K.E = 1/2 m.2ax = max$....... same as (1)

    Thus Work done = Change in Kinetic energy (Work energy theorem).

21.



With the x–and y–axes chosen as shown in Fig. 7.9, the coordinates of points O, A and B forming the equilateral triangle are respectively (0,0), (0.5,0), (0.25,0.25 $\sqrt{3}$). Let the masses 100 g, 150g and 200g be located at O, A and B be respectively. Then, 1

$$X = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{m_1 + m_2 + m_3}$$ 1

$$= \frac{[100(0) + 150(0.5) + 200(0.25)]\ \text{gm}}{(100 + 150 + 200)\ \text{g}}$$

$$= \frac{75 + 50}{450}\text{m} = \frac{125}{450}\text{m} = \frac{5}{18}\text{m}$$

$$Y = \frac{[100(0) + 150(0) + 200(0.25\sqrt{3})]\ \text{gm}}{450\ \text{g}}$$

$$= \frac{50\sqrt{3}}{450}\text{m} = \frac{\sqrt{3}}{9}\text{m} = \frac{1}{3\sqrt{3}}\text{m}$$ 1

22.

Length of sheet, l = 4.234 m

Breadth of sheet, b = 1.005 m

Thickness of sheet, h = 2.01 cm = 0.0201 m

The given table lists the respective significant figures:

Quantity	Number	Significant Figure
l	4.234	4
b	1.005	4
h	2.01	3

Hence, area and volume both must have least significant figures i.e., 3.

Surface area of the sheet = 2 ($l \times b + b \times h + h \times l$)

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

= 2 (4.25517 + 0.02620 + 0.08510)

= 2 × 4.360

= 8.72 m^2

Volume of the sheet = $l \times b \times h$

= 4.234 × 1.005 × 0.0201

= 0.0855 m^3

This number has only 3 significant figures i.e., 8, 5, and 5.

OR (1.5 +1.5)

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

$T=kl^x g^y m^z$ 1

where k is dimensionless constant and x,y and z are the exponents.

By considering dimensions on both sides, we have

$[L^0 M^\circ T^1]=[L^1]x[L^1 T^{-2}]^y[M^1]^z$

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

On equating the dimensions on both sides, we have

$x+y=0; -2y=1;$ and $z=0$ 1

So that $x=1/2, y=-1/2, z=0$

Then, $T=kl^{1/2} g^{-1/2}$

or, $T=k\,(l/g)^{1/2}$

Note that value of constant k cannot be obtained by the method of dimensions. Here it does not matter if some number multiplies the right side of this formula, because that does not affect its dimensions.

Actually, $k=2\pi$ so that $T=2\pi\,(l/g)^{1/2}$ 1

23. (a) Total distance traveled = 23 km (1.5+1.5)

Total time taken = 28 min = 28/60 h

∴Average speed of the taxi = Total Distance Travelled / Total Time Taken

= 23 / (28/60) = 49.29 km/h

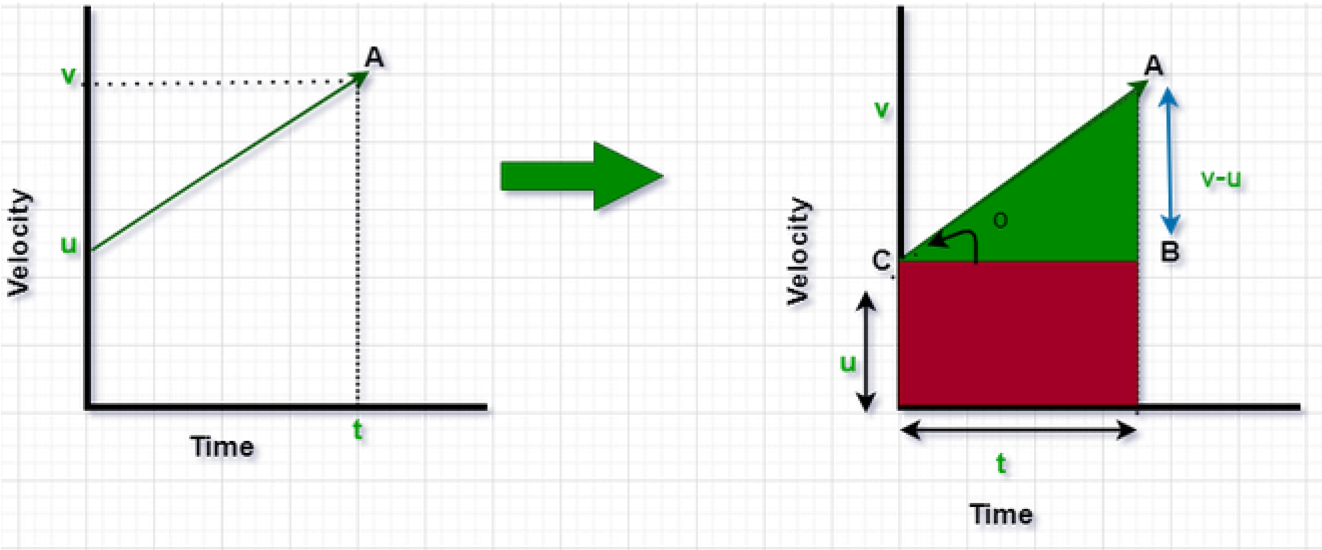
(b) Distance between the hotel and the station = 10 km = Displacement of the car

∴Average velocity = 10 / (28/60) = 21.43 km/h

Therefore, these two : average speed and average velocity are not equal.

24. (1+1+1)

The plot shows that the object has a variable velocity that is increasing from u to v as the slope is positive velocity is increasing in a positive direction.



The velocity-time graph

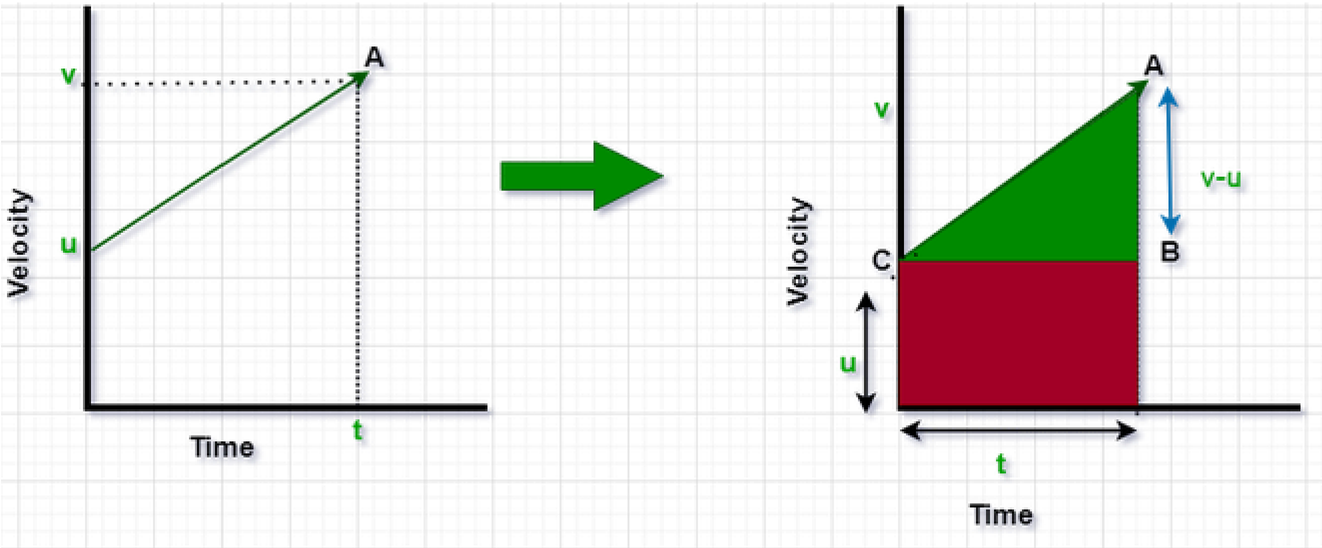
Now we will calculate the acceleration using this motion graph. Acceleration is the tangent of the angle in v-t graph.

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

v= u+at

Derivation of Second equation of motion graphically:

Below v-t graph shows the velocity and time relationship of an object with an initial velocity of u m/s and final velocity of v m/s. As we know the area of the v-t graph gives the displacement of the object, so we will calculate the area of the graph and find out the equation of displacement.



v-t Motion Graph

The Displacement of the object (d) = Area of triangle ABC + Area of rectangle BCOT

Here, the area of the triangle ABC = 1/2 × Base × Height

= 1/2 × t × (v-u)

And the area of the rectangle BCOT = Length × Width

= u × t

Therefore, the displacement of the object, d = 1/2 × t × (v-u) + u × t ……(1)

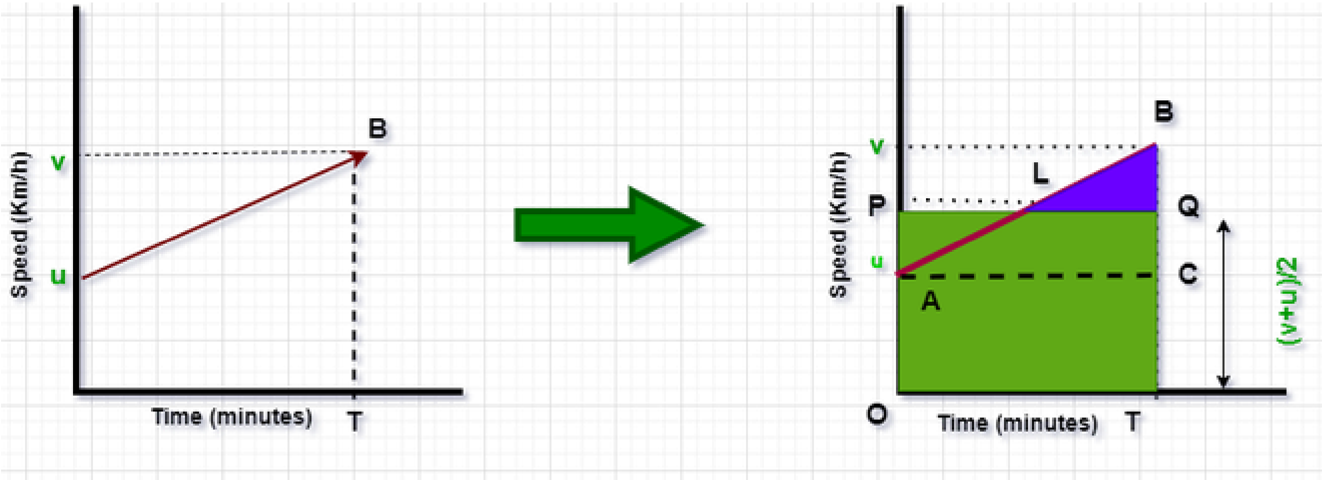
Also, from the first equation of motion, v – u = at

Substitute at for v-u in the equation (1),

$d = 1/2 \times t \times (at) + u \times t$

$d = ut + (1/2)at^2$

Derivation of Third equation of motion graphically:



Original graph to highlighted graph

Here, P is the Centre point, so the speed of the object is (v + u) / 2.

Therefore, the displacement of the object (d) = the area of the triangle ABC + the area of the rectangle ACTO = the area of the rectangle OPQT

The displacement of the object, d = Length × Width

$= t \times (v + u)/2$ ……(2)

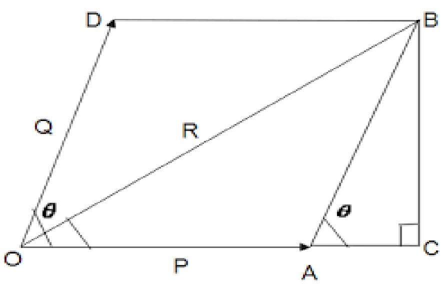
Also, from the first equation of motion, v – u = at or t = (v – u) / a

Therefore, the equation (2) becomes:

$d = (v – u) / a \times (v + u) / 2$

$v^2 = u^2 – 2ad$

25.



1

So, $R = P + Q$

From triangle OCB

$OB^2 = OC^2 + BC^2$

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

In ΔABC

$$\cos\theta = \frac{AC}{AB}$$

$AC = AB\cos\theta$

$AC = OD\cos\theta = Q\cos\theta$

as $[AB = OD = Q]$

Also

$$\cos\theta = \frac{BC}{AB}$$

$BC = AB\sin\theta$

$BC = OD\sin\theta = Q\sin\theta$

[as $AB = OD = Q$]

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

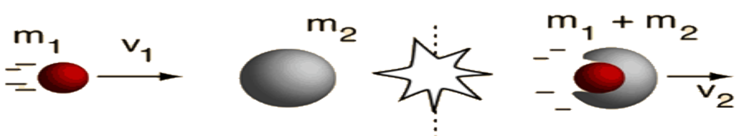
$R^2 = (P + Q\cos\theta)^2 + (Q\sin\theta)^2$

$\therefore R = \sqrt{P^2 + 2PQ\cos\theta + Q^2} \rightarrow$ Magnitude

2

26. Statement-1/2
    Prove- 1.5
    Example- 1

27. 3



From conservation of momentum:

$$m_1 v_1 = (m_1 + m_2)v_2 \Rightarrow v_2 = \frac{m_1}{m_1 + m_2} v_1$$

The ratio of kinetic energies before and after is:

$$\frac{KE_f}{KE_i} = \frac{\frac{1}{2}(m_1 + m_2)\left[\frac{m_1}{m_1 + m_2} v_1\right]^2}{\frac{1}{2} m_1 v_1^2} = \frac{m_1}{m_1 + m_2}$$

The fraction of kinetic energy lost is:

$$\frac{KE_i - KE_f}{KE_i} = \frac{\left[1 - \frac{m_1}{m_1 + m_2}\right] KE_i}{KE_i} = \frac{m_2}{m_1 + m_2}$$

28. (1.5 +1.5)

$$E = \frac{1}{2}I\omega^2 = \frac{1}{2} \times \frac{1}{2} MR^2 \times \omega^2$$

$$= \frac{1}{4} \times 20 \times 25 \times 25 \times 100 \times 100$$

$$= 3125\ J$$

Angular momentum = $I\omega$

$$= \frac{1}{2} \times 20 \times .25 \times .25 \times 100$$

$$= 62.5\ Js.$$

29. (i) (b) First, the car B moves backward and then forward 1
 (ii) (d) First, the car A moves forward and then backward forward 1
 (iii) (c)First increases, then decreases and finally increases again 1
 (iv) (a) 62.5 m due North of starting point 1
 OR
 (a) 25 m due North of starting point
30. (i) (b) 500J 1
 (ii) (b) 10^4 J 1
 (iii) less than ½ mv^2 1
 (iv) (a) 1.4 s 1

Let m be the mass of the unloaded car. Then,

$\frac{1}{2}mu^2 = FS$----------(i)

where F = retarding force.

When 40% weight is added, new mass is given by:

$m_1 = m + (\frac{40}{100})m = 1.4m$

Now, $\frac{1}{2}m_1u^2 = FS_1$

or, $\frac{1}{2} \times 1.4mu^2 = FS_1$-------(ii)

So, from (i) and (ii), we can write:

$S_1 = 1.4S$

Or (d) 475J

Initial K.E., $E_1 = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 10 \times (10)^2 = 500\ J$

At $x = 20$ m, retarding force,

$F_1 = 0.1 \times 20 = 2\ N$

At $x = 30$ m, retarding force,

$F_2 = 0.1 \times 30 = 3\ N$

Average Retarding Force,

$F = \frac{F_1 + F_2}{2} = \frac{2+3}{2} = 2.5\ N$

Work done by retarding force

= loss in K.E.

$= F \times s = 2.5\ (30 - 20) = 25\ J$

Final K.E. = E_1 − loss in K.E.

$= 500 - 25 = 475\ J$

31. Prof of the path of projectile motion- 2
 Time of flight+ range+ maximum height- 1+1+1

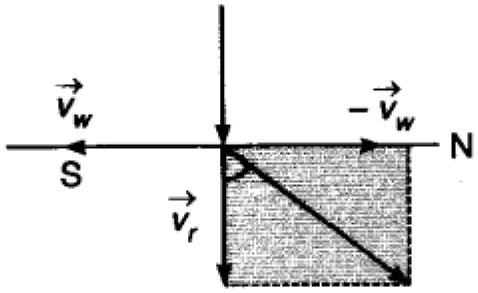
Or

Definition- 1

Derivation of Expression- 2

Numerical- 2

Velocity of rain relative to the women of cycle is



$$\vec{v}_{rw} = \vec{v}_r - \vec{v}_w$$

$$\tan\theta = \frac{v_w}{v_r} = \frac{10}{30} = \frac{1}{3}$$

$$= 0.3333$$

$$\theta = 18°26'$$ 1

with vertical towards south.

32. (a) Definition- 1

Derivation of Expression- 2

(b) Required centripetal force= $\frac{mv2}{r}$ 1

= 3920N

Force of friction= µmg= 5880 N 1

As the friction force is greater than centripetal force, so the vehicle will not skid.

Or

(a) Static friction is a self-adjusting force because it comes into play when the body is lying over the surface of another body without any motion. When that body overcomes the force of static friction, the maximum value of static friction is reached, which is known as limiting friction. 2

(b) (i) lubricating the surfaces.
(ii) use of ball bearings (i.e. replacing sliding friction with rolling friction)
(iii) streamlining the body.
other ways also accepted 2

(c) Ball bearings are used for controlling oscillatory and rotational motion. For example, in electrical motors where the shaft is free to rotate but the motor housing is not, ball bearings are used to connect the shaft to the motor housing. 1

33. (a) Quantitative measure of the rotational inertia of a body—i.e., the opposition that the body exhibits to having its speed of rotation about an axis altered by the application of a torque (turning force).
SI unit kgm^2.
Dimensions- $[ML^2T^0]$ 1+1+1

Factors on which the moment of inertia of a body depends.

(i) The size and shape of the body.
(ii) The axis of rotation.
(iii) The distribution of mass about the axis. The moment of inertia of a body about a given axis is the sum of the products of the masses of each particles and squares of perpendicular distance from the axis of rotation.

(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) 3

Consider a body rotating about an axis.
When a torque τ is applied, its angular velocity changes.
This produces an angular acceleration which will be the same for each particle
but linear acceleration is different for different particles.
Let the body be made up of a number of particles of masses m_1, m_2, m_3......*situat*
distances r_1, r_2, r_3....*from* the axis.
The linear velocity of the particle of mass m_1 is:
$v_1 = r_1\omega$ where ω is the angular velocity

Linear acceleration, $a_1 = \frac{dv_1}{dt} = \frac{d}{dt}(r_1\omega) = r_1\frac{d\omega}{dt}$

$\frac{d\omega}{dt}$ is the angular acceleration α

$\therefore a_1 = r_1\alpha$

The force acting on the first particle, $f_1 = m_1a_1$

i.e. $f_1 = m_1r_1\alpha = m_1r_1\frac{d\omega}{dt}$

Torque or moment of force f_1 about the axis of rotation is:

$\tau_1 = f_1 \times r_1 = m_1r_1^2\frac{d\omega}{dt} = m_1r_1^2\alpha$

Therefore the torque due to forces f_1, f_2, f_3......acting on different particles are
$m_2r_2^2\alpha, m_3r_3^2\alpha$.......

i.e. $\tau_1 = m_1r_1^2\alpha$, $\tau_2 = m_2r_2^2\alpha$, $\tau_3 = m_3r_3^2\alpha$.........

Total torque , $\tau = \tau_1 + \tau_2 + \tau_3 +$........

i.e. $\tau = m_1r_1^2\alpha + m_2r_2^2\alpha + m_3r_3^2\alpha +$......

$\tau = [m_1r_1^2 + m_2r_2^2 + m_3r_3^2 + ...]\alpha$

$\tau = \sum mr^2\alpha$

We know that $\sum mr^2 = I$ (Moment of inertia of the body about the axis)

$\Rightarrow \tau = I\alpha$

(b) **a** =3**i**-4**j**+5**k** and **b** =-2**i**+**j**+3**k**

a.b = -6-4+15= 5unit 1

aXb =3**k**-9**j**-8**k**-12**i**-10**j**-5**i**

=-17**i**-19**j**-5**k** **1**

----------------**ALL THE BEST**---------------