UNIT-2 KINEMATICS

MY REVISION TIMELINE:-

SUMMARY:-

- A state of rest or motion is defined with respect to a frame of reference.
- In physics, we follow right handed Cartesian coordinate system to explain the motion of objects.
- To explain linear motion, the concept of point mass is used.
- A scalar has only magnitude.
- A vector has both magnitude and direction.
- The length of a vector is called magnitude or norm of the vector.
- In Cartesian coordinate system, the unit vectors are orthogonal to each other.
- Vectors can be added either by triangular law of addition or by parallelogram law of addition.
- Any vector can be resolved into three components with respect to Cartesian coordinate system.
- If two vectors are equal, then their corresponding individual components should be separately equal.
- The direction of $\hat{n}$ can be found using right hand thumb rule or right hand cork screw rule.
- Distance is a scalar quantity. Distance is the total path length travelled by the particle.
- Displacement is a vector quantity. Displacement is the difference between the initial and the final position.
- Average velocity and instantaneous velocity are vector quantities.
- For constant acceleration, kinematic equations can be used to analyse motion of a particle.
- In projectile motion for which acceleration is uniform, the path traced by the particle is a parabola.
- The maximum height and range of the particle in projectile motion depends inversely on acceleration due to gravity g.
- The centripetal acceleration is always directed towards the centre of the circle.

FORMULAS:-

- The magnitude or norm of a vector $|\bar{A}| = A = \sqrt{A_{x^2} + A_{y^2} + A_{z^2}}$
- The unit vector $\hat{A} = \frac{\vec{A}}{A}$
- Magnitude of resultant vector $|\vec{R}| = R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$ (addition of vectors)
- Magnitude of resultant vector $|\vec{R}| = R = \sqrt{A^2 + B^2 - 2AB\cos\theta}$ (subtraction of vectors)

- Direction of resultant vector $\alpha = \tan^{-1}(\frac{B\sin\theta}{A+B\cos\theta})$ (addition of vectors)
- Direction of resultant vector $\alpha = \tan^{-1}(\frac{B\sin\theta}{A-B\cos\theta})$ (subtraction of vectors)
- Scalar product $\vec{A}\cdot\vec{B} = AB\cos\theta$
- Vector product $\vec{A}\times\vec{B} = (AB\sin\theta)\hat{n}$
- The vector product of two vectors is $\vec{A}\times\vec{B}\begin{matrix}\hat{\imath} & \hat{\jmath} & \hat{k}\\ A_x & A_y & A_z\\ B_x & B_y & B_z\end{matrix}$

  $= \hat{\imath}(A_yB_z - A_zB_y) + \hat{\jmath}(A_xB_z - A_zB_x) + \hat{k}(A_xB_y - A_yB_x)$
- Area of a triangle = $\frac{1}{2}|\vec{A}\times\vec{B}|$
- Torque = $\vec{\tau} = \vec{r}\times\vec{F}$
- Angular momentum $\vec{L} = \vec{r}\times\vec{p}$
- Linear velocity $\vec{v} = \vec{\omega}\times\vec{r}$
- $\omega = \vec{F}\cdot\overrightarrow{dr} = Fdr\cos\theta$
- Force $\vec{F} = m\vec{a}$
- Linear momentum $\vec{p} = m\vec{v}$
- Force $\vec{F} = q\vec{E}$
- The scalar product is $\vec{A}\cdot\vec{B} = (A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k})\cdot(B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k})$
  $= A_xB_x + A_yB_y + A_zB_z$
- The position vector of a particle is $\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$
- The displacement vector is $\Delta\vec{r} = \overrightarrow{r_2} - \overrightarrow{r_1}$
- $\frac{dy}{dx} = \lim \Delta x \to 0\ \frac{\Delta y}{\Delta x}$
- $y = x^n$, $\frac{dy}{dx} = nx^{n-1}$
- Average velocity = $\vec{v}_{avg} = \frac{\Delta\vec{r}}{\Delta t}$
- Average speed is $\frac{total\ path\ length}{total\ time}$
- Instantaneous velocity or velocity is $\vec{v} = \lim_{\Delta t\to 0}\frac{\Delta\vec{r}}{\Delta t} = \frac{d\vec{r}}{dt}$
- Relative velocity of object A with respect to object B is $\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$
- Relative velocity of object B with respect to object A is $\vec{v}_{BA} = \vec{v}_B - \vec{v}_A$
- Velocities $\vec{v}_A$ and $\vec{v}_B$ are at an angle θ, then $\vec{v}_{AB} = \sqrt{v_A^2 + v_B^2 + 2v_Av_B\cos\theta}$,
  tanB = $\frac{v_B\sin\theta}{v_A - v_B\cos\theta}$
  - When both move in same direction $v_{AB} = v_A - v_B$
  - When both move in opposite direction $v_{AB} = v_A + v_B$
  - When they are perpendicular $v_{AB} = \sqrt{v_A^2 + v_B^2}$, $\tan\theta = \frac{v_B}{v_A}$
- Average acceleration is $\vec{a}_{avg} = \frac{\Delta\vec{v}}{\Delta t}$
- Instantaneous acceleration or acceleration is $\vec{a} = \lim_{\Delta t\to 0}\frac{\Delta\vec{v}}{\Delta t} = \frac{d\vec{v}}{dt}$
- Kinematics equation for linear motion
  - Velocity v = u + at
  - Linear displacement s = ut + $\frac{1}{2}$at^2
  - Linear displacement s = $\frac{(v+u)t}{2}$

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- Velocity $v^2 = u^2 + 2as$

- Kinematics equation for angular motion
  - Angular velocity $\omega = \omega_o + \alpha t$
  - Angular displacement $\theta = \omega_o + \frac{\alpha t^2}{2}$
  - Angular displacement $\theta = \frac{(\omega_o + \omega)t}{2}$
  - Angular velocity $\omega^2 = \omega_o^2 + 2\alpha\theta$
- Horizontal projection
  - Time of flight $T = \sqrt{\frac{2h}{g}}$
  - Horizontal Range $R = u\sqrt{\frac{2h}{g}}$
  - Resultant velocity $v = gt$
  - Speed of projectile when it hits the ground $v = \sqrt{2gh}$
  - Motion along horizontal direction $x = u_x t$
  - Motion along downward direction $y = \frac{gt^2}{2}$
- Angular projection
  - Maximum height $H_{max} = \frac{u^2 sin^2\theta}{2g}$
  - Time of flight $T_f = \frac{2usin\theta}{g}$
  - Horizontal Range $R = \frac{u^2 sin2\theta}{g}$
  - Maximum Range $R_{max} = \frac{u^2}{g}$ when $\theta = \frac{\pi}{4}$
  - Horizontal distance $x = ucos\theta \cdot t$
  - Vertical distance $y = usin\theta t - \frac{gt^2}{2}$
- Equations of motion for freely falling bodies
  - Case i) A body falling from height h
    $v = u + gt$
    $s = ut + \frac{1}{2}gt^2$
    $v^2 = u^2 + 2gy$
  - Case ii) A body thrown vertically upwards
    $v = u - gt$
    $v = ut - \frac{1}{2}gt^2$
    $v^2 = u^2 - 2gy$

- 2π radians = 360°
- Angular displacement $\theta = \frac{s}{r}$
- Angular velocity $\vec{\omega} = \frac{d\theta}{dt}$
- Angular acceleration $\vec{\alpha} = \frac{d\vec{w}}{dt}$
- Relation between linear velocity and angular velocity $\vec{v} = \vec{\omega} \times \vec{r}$
- Tangential acceleration $a_t = r\alpha$
- Centripetal acceleration $a_c = \frac{-v^2}{r}$ or $a_c = -\omega^2 r$
- Magnitude of resultant acceleration is $a_R = \sqrt{at^2 + (\frac{v^2}{r})^2}$
- Angle of resultant acceleration is $\tan\theta = \frac{a_t}{(\frac{v^2}{r})}$

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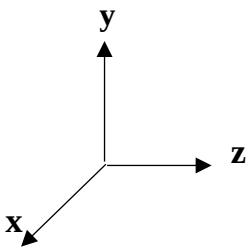
MULTIPLE CHOICE QUESTIONS:-

1. **Which one of the following Cartesian coordinate systems is not featured in physics?**

d)



Solution:

It is left handed Cartesian coordinate system. In physics, we conventionally follow right handed Cartesian coordinate system to explain the motion of objects.

2. **Identify the unit vector in the following.**

d) $\frac{\hat{\imath}+\hat{\jmath}}{\sqrt{2}}$

Solution:

Unit vector $\hat{A} = \frac{\vec{A}}{A}$ *(1,1)*

$$\hat{A} = \frac{\vec{\imath}+\vec{\jmath}}{\sqrt{i^2+j^2}}$$

$$\hat{A} = \frac{\vec{\imath}+\vec{\jmath}}{\sqrt{1+1}}$$

$$\boxed{\hat{A} = \frac{\hat{\imath}+\hat{\jmath}}{\sqrt{2}}}$$

3. **Which one of the following physical quantities cannot be represented by a scalar?**

c) Momentum

Solution:

Mass – Scalar quantity

Length – Scalar quantity

Momentum → Product of mass and velocity where mass is a scalar quantity and velocity is a vector quantity. Hence it is a vector quantity.

Magnitude of acceleration – Scalar quantity

4. **Two objects of masses m_1 and m_2 fall from the heights h_1 and h_2 respectively. The ratio of the magnitude of their momenta when they hit the ground is**

c) $\frac{m_1}{m_2}\sqrt{\frac{h_1}{h_2}}$

Solution:

$v^2 = u^2 + 2as$

Here u=0, a=g, s=h

$v^2 = 0 + 2gh$

$v^2 = \sqrt{2gh}$

$p = mv$

$$\frac{p_1}{p_2} = \frac{m_1 v_1}{m_2 v_2}$$

$$\frac{p_1}{p_2} = \frac{m_1\sqrt{2gh_1}}{m_2\sqrt{2gh_2}}$$

$$\boxed{\frac{p_1}{p_2} = \frac{m_1\sqrt{h_1}}{m_2\sqrt{h_2}}}$$

5. If a particle has negative velocity and negative acceleration, it's speed

a) Increases

Solution:

If a particle has negative velocity and negative acceleration, it moves opposite direction of motion. The speed of particle increases with increasing time in opposite direction.

6. If the velocity is $\vec{v} = 2\vec{\imath} + t^2\vec{\jmath} - 9\vec{k}$, then the magnitude of acceleration at t=0.5s is

a) $1ms^{-1}$

Solution:

$a = \frac{dv}{dt}$

$a = \frac{d(2\vec{\imath}+t^2\vec{\jmath}-9\vec{k})}{dt}$

$a = 0 + 2t + 0$

$a = 2t$

$a = 2(0.5)$

$$\boxed{a = 1ms^{-1}}$$

7. If an object is dropped from the top of a building and it reaches the ground at t=4s, then the height of the building is (ignoring resistance) ($g=9.8ms^{-2}$)

b) 78.4 m

Solution:

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

Here t=4s, s=h, u=0, a=g

$h = 0(4) + \frac{1}{2}g(4)^2$

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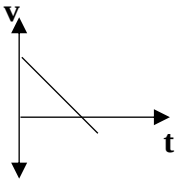
$h = \frac{1}{2}(9.8)(16)$

$\boldsymbol{h = 78.4m}$

8. A ball is projected vertically upwards with a velocity v. It comes back to the ground in time t. Which v-t graph shows the motion correctly?

c)



Solution:

At maximum height, velocity of the ball becomes zero and the ball starts its backward journey in negative direction.

9. If one object is dropped vertically downward and another object is thrown horizontally from the same height, then the ratio of vertical distance covered by both the objects at any instant is

a) 1

Solution:

When object is dropped vertically downward

$s_y = u_y t + \frac{1}{2}at^2$

Here $s_y = h$, $u_y = 0$, $a = g$

$h = 0(t) + \frac{1}{2}gt^2$

$h_1 = \frac{1}{2}g_1t^2$

$$\frac{h_1}{h_2} = \frac{\frac{gt^2}{2}}{\frac{gt^2}{2}}$$

$$\frac{h_1}{h_2} = 1$$

When object is thrown horizontally

$s_y = u_y t + \frac{1}{2}at^2$

Here $s_y = h$, $u_y = 0$, $a = g$

$h = 0(t) + \frac{1}{2}gt^2$

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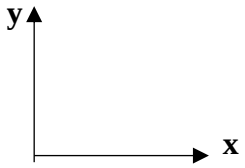
$h_2 = \frac{1}{2}gt^2$

10. A ball is dropped from some height towards the ground. Which one of the following represents the correct motion of the ball?

a) 

Solution:

When an object falls from some height towards the ground, the speed of the object increases rapidly.

11. If a particle executes uniform circular motion in xy plane in clockwise direction, then the angular velocity is in

c) –z direction

Solution:

On using right hand rule we note that

i) When motion is in anticlockwise in xy plane, then +z is the direction of angular velocity

ii) When motion is in clockwise in xy plane, then -z is the direction of angular velocity

12. If a particle executes uniform circular motion _____

Choose the correct answer

d) The speed and magnitude of acceleration are constant

Solution:

In uniform circular motion, velocity and acceleration are not constant. Hence the speed and magnitude of acceleration are constant.

13. If an object is thrown vertically up with the initial speed u from the ground, then the time taken by the object to return back to ground is

d) $\frac{2u}{g}$

Solution:

When body moves upward

$v = u+at$

Here v=0, u=-g

$0 = u - gt$

$gt = u$

$t = \frac{u}{g} \rightarrow (1)$

When body moves downward

$v^2 = u^2+2as$

Here v=0, a=-g, s=h

$0 = u^2-2gs$

$h = \frac{u^2}{2g}$

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

Here s=-h, u=0, a=-g

$-h = 0(t) - \frac{1}{2}gt^2$

$h = \frac{1}{2}gt^2$

$\frac{u^2}{2g} = \frac{1}{2}gt^2$

$t^2 = \frac{u^2}{g^2}$

$t = \frac{u}{g} \rightarrow (2)$

From equations 1 and 2 $=> \frac{u}{g} + \frac{u}{g}$

$$= \frac{2u}{g}$$

14. Two objects are projected at angles 30° and 60° respectively with respect to the horizontal direction. The range of two objects are denoted as $R_{30°}$ and $R_{60°}$. Choose the correct relation from the following.

a) R30° = R60°

Solution:

When $\theta = 30°$

$R = \frac{u^2 sin2\theta}{g}$

$R_1 = \frac{u^2 sin2(30°)}{g}$

$R_1 = \frac{u^2 sin(60°)}{g}$

$R_1 = \frac{u^2\sqrt{3}}{2g}$

When $\theta = 60°$

$R = \frac{u^2 sin2\theta}{g}$

$R_2 = \frac{u^2 sin2(60°)}{g}$

$R_2 = \frac{u^2 sin(120°)}{g}$

$R_2 = \frac{u^2\sqrt{3}}{2g}$

$R_1 = R_2$ Hence R30° = R60°

15. An object is dropped in an unknown planet from height 50m, it reaches the ground in 2s. The acceleration due to gravity in this unknown planet is

b) 25ms^{-1}

Solution:

$T = \sqrt{\frac{2h}{g}}$

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$T^2 = \frac{2h}{g}$

$g = \frac{2h}{T^2}$

$g = \frac{2(50m)}{(2s)^2}$

$g = \frac{2(50m)}{4s^2}$

$\boldsymbol{g = 25ms^{-2}}$

NUMERICAL PROBLEMS:-

1. Given:

$\vec{r} = 1m$

$\theta = 30°$

Length of x and y components = ?

Formula used:

Length of x component = rcosθ

Length of y component = rsinθ

Solution:

Length of x component $= rcos\theta$

$= 1(cos30°)$

$= \frac{\sqrt{3}}{2}$

$= 0.866$

$\boldsymbol{= 0.87m}$

Length of y component $= rsin\theta$

$= 1(sin30°)$

$= \frac{1}{2}$

$\boldsymbol{= 0.5m}$

2. Given:

$\vec{r_1} = 3\vec{\imath} + 4\vec{\jmath}, \vec{r_2} = \vec{\imath} + 2\vec{\jmath}$

$\Delta\vec{r}$ *= ? To draw* $\vec{r_1}, \vec{r_2}$ *and* $\Delta\vec{r}$

Formula used:

$\Delta\vec{r} = \vec{r_2} - \vec{r_1}$

Solution:

$\Delta\vec{r} = \vec{r_2} - \vec{r_1}$

$\Delta\vec{r} = \vec{\imath} + 2\vec{\jmath} - (3\vec{\imath} + 4\vec{\jmath})$

$\boldsymbol{\Delta\vec{r} = -2\vec{\imath} - 2\vec{\jmath}}$

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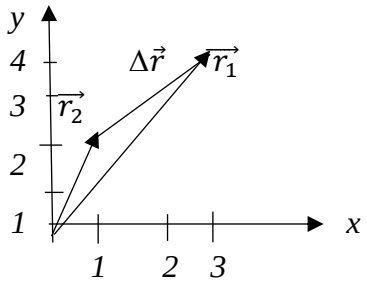

3. Given:

$\overrightarrow{r_1} = 5\vec{\imath} + 6\vec{\jmath}$, $\overrightarrow{r_2} = 2\vec{\imath} + 3\vec{\jmath}$, t=5s, $\vec{v}_{avg} = ?$

Formula used:

$$\vec{v}_{avg} = \frac{\Delta\vec{r}}{\Delta t} = \frac{\overrightarrow{r_2} - \overrightarrow{r_1}}{dt}$$

Solution:

$$\vec{v}_{avg} = \frac{2\vec{\imath} + 3\vec{\jmath} - (5\vec{\imath} + 6\vec{\jmath})}{5}$$

$$\vec{v}_{avg} = \frac{-3\vec{\imath} - 3\vec{\jmath}}{5}$$

$$\boxed{\vec{v}_{avg} = \frac{-3(\vec{\imath} + \vec{\jmath})}{5}}$$

4. Given:

To convert $\vec{r} = 3\vec{\imath} + 2\vec{\jmath}$ *into unit vector.*

Formula used:

Unit vector $\hat{r} = \frac{\vec{r}}{|\vec{r}|}$

Solution:

$$\hat{r} = \frac{3\vec{\imath} + 2\vec{\jmath}}{\sqrt{3^2 + 2^2}}$$

$$\hat{r} = \frac{3\vec{\imath} + 2\vec{\jmath}}{\sqrt{9 + 4}}$$

$$\boxed{\hat{r} = \frac{3\vec{\imath} + 2\vec{\jmath}}{\sqrt{13}}}$$

5. Given:

$\vec{A} = 4\vec{\imath} - 2\vec{\jmath} + \vec{k}$,

$\vec{B} = 5\vec{\imath} + 3\vec{\jmath} - 4\vec{k}$

$\vec{A} \times \vec{B} = ?$

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Solution:

$$\vec{A} \times \vec{B} = \begin{matrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 4 & -2 & 1 \\ 5 & 3 & -4 \end{matrix}$$

$\vec{A} \times \vec{B} =$ *î(8-3)- ĵ(-16-5)+ k̂(12-(-10))*

$$\boxed{\vec{A} \times \vec{B} = 5\vec{\imath} + 21\vec{\jmath} + 22\vec{k}}$$

6. Given:

$R = 4H_{max}$, $\theta = ?$

Formula used:

$$R = \frac{u^2 sin2\theta}{g}$$

$$H_{max} = \frac{u^2 sin^2\theta}{g}$$

Solution:

$$R = 4\, H_{max}$$

$$\frac{u^2 sin2\theta}{g} = 4\frac{u^2 sin^2\theta}{2g}$$

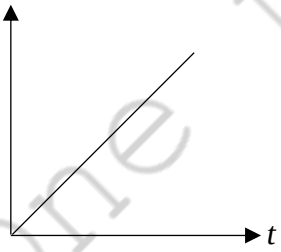
$$\frac{sin\,\theta}{cos\,\theta} = 1$$

$$tan\theta = 1$$

$$\boxed{\theta = 45°}$$

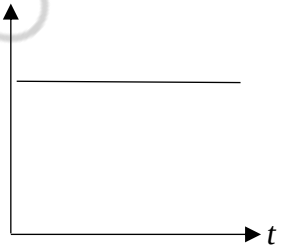
7. Solution:

a) *v*



$\vec{a}$ = *constant*

b) *v*



$\vec{v}$ = *constant*

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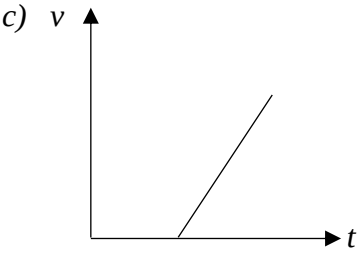
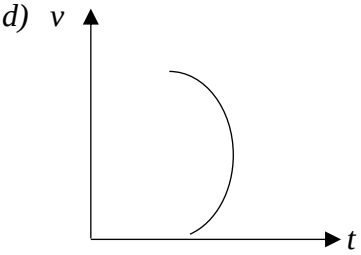
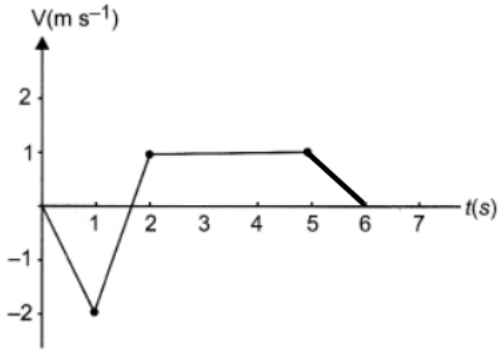
c) 

$\vec{a}$ *= constant but greater than graph a)*

d) 

$\vec{a}$ *is variable*

8. Given:



Distance and displacement from 0 to 2s =?

Solution:

- *0s to 1s:*

  Displacement = $(\frac{1}{2})(1)(-2) = -1m$

  Distance = 1m
- *1s to 1.5s:*

  Displacement = $(\frac{1}{2})(0.5)(-2) = -0.5m$

  Distance = 0.5m
- *1.5s to 2s:*

  Displacement = $(\frac{1}{2})(0.5)(1) = 0.25m$

  Distance = 0.25m

Displacement from 0s to 2s = -1 -0.5 +0.25 **= -1.25m**

Distance from 0s to 2s = 1 +0.5 +0.25 **= 1.75m**

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9. Given:

Match

Solution:

- v_x = *Remains constant*
- v_y = *Decreases and increases*
- *Acceleration = Remains downward*
- *Position vector = Varies*

10. Given:

R_{max} *is the area covered*

Formula used:

Area $= \pi r^2$

Solution:

Area covered $= \pi r^2$

$= \pi R_{max}^2$

$= \pi(\frac{v^2}{g})^2$

$$= \pi \frac{v^4}{g^2}$$

11. Given:

Range $= \frac{u^2 sin2\theta}{g}$

$R \alpha \frac{1}{g}$ *i.e* $g \alpha \frac{1}{R}$

Solution:

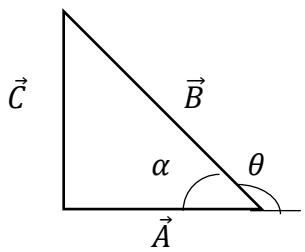
Acceleration due to gravity g:

- *Jupiter* $= \frac{1}{R} = \frac{1}{50} = 0.02ms^{-1}$
- *Earth* $= \frac{1}{R} = \frac{1}{75} = 0.013ms^{-1}$
- *Mars* $= \frac{1}{R} = \frac{1}{90} = 0.011ms^{-1}$
- *Mercury* $= \frac{1}{R} = \frac{1}{95} = 0.010ms^{-1}$

Planets in ascending order according to their acceleration due to gravity g is

Mercury, Mars, Earth, Jupiter

12. Given:



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$\vec{C} = \frac{1}{2}\vec{B}$

Solution:

$sin\alpha = \frac{\vec{C}}{\vec{B}}$

$sin\alpha = \frac{\frac{\vec{B}}{2}}{\vec{B}}$

$sin\alpha = \frac{1}{2}$

$\alpha = 30°$

$\theta = 180° - \alpha$

$\theta = 180° - 30°$

$\boldsymbol{\theta = 150°}$

13. Solution:

- $T\vec{j} - mg\vec{j} = ma\vec{j}$ => *T-mg = ma*
- $\vec{T} + \vec{F} = \vec{A} + \vec{B}$ => $T_x + F_x = A_x + B_x$ *or* $T_y + F_y = A_y + B_y$
- $\vec{T} - \vec{F} = \vec{A} - \vec{B}$ => $T_x - F_x = A_x - B_x$ *or* $T_y - F_y = A_y - B_y$
- $T\vec{j} + mg\vec{j} = ma\vec{j}$ => *T+mg = ma*

14. Given:

$\vec{A} = 5\vec{\imath} - 3\vec{j}$,

$\vec{B} = 4\vec{\imath} - 6\vec{j}$

Area of triangle = ?

Formula used:

Area of triangle = $\frac{1}{2}|\vec{A} \times \vec{B}|$

Solution:

$$\vec{A} \times \vec{B} = \begin{matrix} \hat{\imath} & \hat{j} & \hat{k} \\ 5 & -3 & 0 \\ 4 & 6 & 0 \end{matrix}$$

$\vec{A} \times \vec{B} =$ *î(0-0)- ĵ(0-0)+* $\hat{k}$*(30-(-12))*

$\vec{A} \times \vec{B} = 42\hat{k}$

$|\vec{A} \times \vec{B}| = \sqrt{42^2}$

$\left|\vec{A} \times \vec{B}\right| = 42$

Area of triangle $= \frac{1}{2}|\vec{A} \times \vec{B}|$

$= \frac{42}{2}$

= 21 squared units

15. Given:

1 revolution = 360°

Solution:

360° in 24 hours:

Angular displacement in 1 hour = $\frac{360°}{24}$

= 15° in terms of degree measure

1 radian = $\frac{180°}{\pi}$, *1°* = $\frac{\pi}{180°}$

⇨ $\frac{\pi}{180°} \times 15°$

⇨ $\frac{\pi}{12}$ ***radians in terms of radian measure***

16. Given:

$u = 5ms^{-1}$, $\theta = 30°$, H_{max}, $R = ?$

Formula used:

$$H_{max} = \frac{u^2 sin^2\theta}{2g}$$

$$R = \frac{u^2 sin2\theta}{g}$$

Solution:

$$H_{max} = \frac{u^2 sin^2\theta}{2g}$$

$$H_{max} = \frac{(5)^2 sin^2 30°}{2(9.8)}$$

$$H_{max} = \frac{25 \times (\frac{1}{2})^2}{2(9.8)}$$

$$H_{max} = \frac{25}{78.4}$$

H_{max} = 0.318m

$$R = \frac{u^2 sin2\theta}{g}$$

$$R = \frac{(5)^2 sin2(30°)}{9.8}$$

$$R = \frac{25 \times sin(60°)}{9.8}$$

$$R = \frac{25 \times \frac{\sqrt{3}}{2}}{9.8}$$

$$R = 2.209$$

R = 2.21m

17. Given:

$u = 20ms^{-1}$, $\theta = 30°$

Goal post distance = 40m

Does ball reach goal post = ?

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Formula used:

$R = \frac{u^2 sin2\theta}{g}$

Solution:

$R = \frac{u^2 sin2\theta}{g}$

$R = \frac{(20)^2 sin2(30°)}{9.8}$

$R = \frac{400 \times sin(60°)}{9.8}$

$R = \frac{400 \times \frac{\sqrt{3}}{2}}{9.8}$

$R = \frac{173.2}{4.9}$

R = 35.3m

The ball doesn't reach the goal post since the goal post distance is 40m and the range fo the ball is 35.3m.

18. Given:

$u = 10ms^{-1}$, h = 100m, s = ?

Formula used:

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

Solution:

Horizontal distance covered by particles:

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

Here a = 0

=> s = ut

To find t:

Vertical distance:

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

Here u = 0

$100 = (0)t + \frac{1}{2}(9.8)t^2$

$t^2 = \frac{2 \times 100}{9.8}$

t = 4.5s

s = ut

$s = (10ms^{-1})(4.5s)$

s = 45m

19. Given:

Angular speed = $\frac{\pi}{12}$ rad per sec, t = 4s

Angular displacement = ?

Formula used:

Angular velocity = $\frac{Angular\ displacement}{Time}$

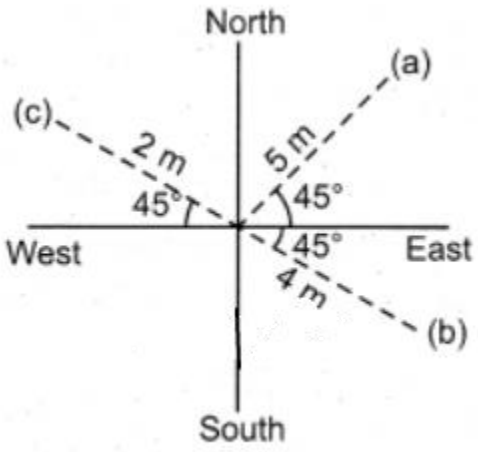
Solution:

$\frac{\pi}{12} = \frac{Angular\ displacement}{4}$

Angular displacement $= \frac{4 \times 180^\circ}{12}$

Angular displacement = 60°

20. Given:



Solution:

a) 5m north east and 2m up

- *Length along x axis = 5 cos45°* $= \frac{5}{\sqrt{2}}$
- *Length along y axis = 5 sin45°* $= \frac{5}{\sqrt{2}}$
- *Length along z axis = 2*
- *Vector notation* $= \frac{5}{\sqrt{2}}\vec{\imath} + \frac{5}{\sqrt{2}}\vec{\jmath} + 2\vec{k}$
  $= \frac{5}{\sqrt{2}}(\vec{\imath} + \vec{\jmath}) + 2\vec{k}$

b) 4m south east and 3m up

- *Length along x axis = 4 cos45°* $= \frac{4}{\sqrt{2}}$
- *Length along y axis = -4 sin45°* $= \frac{4}{\sqrt{2}}$
- *Length along z axis = 3*
- *Vector notation* $= \frac{4}{\sqrt{2}}\vec{\imath} + \frac{4}{\sqrt{2}}\vec{\jmath} + 3\vec{k}$
  $= \frac{4}{\sqrt{2}}(\vec{\imath} - \vec{\jmath}) + 3\vec{k}$

c) 2m north west and 4m up

- *Length along x axis = -2 cos45°* $= \frac{-2}{\sqrt{2}} = -\sqrt{2}$
- *Length along y axis = 2 sin45°* $= \frac{2}{\sqrt{2}} = \sqrt{2}$
- *Length along z axis = 4*
- *Vector notation* $= -\sqrt{2}\vec{\imath} + \sqrt{2}\vec{\jmath} + 4\vec{k}$
  $= \sqrt{2}(-\vec{\imath} + \vec{\jmath}) + 4\vec{k}$

21. Given:

Moon orbiting the Earth once in 27 days = 360°

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Solution:

Angle transversed by moon per day $= \frac{360°}{27}$

= *13.3°*

22. Given:

$\alpha = 0.2\ rads^{-2}$

$t = 3s$

$\omega_0 = 0$

$\theta = ?$

Formula used:

$$\theta = \omega_o t + \frac{\alpha t^2}{2}$$

Solution:

$$\theta = \omega_o t + \frac{\alpha t^2}{2}$$

$$\theta = (0)3 + \frac{(0.2)(3)^2}{2}$$

$$\theta = 0.9\ rad$$

Degree $= 0.9 \times 57.27°$

$= 51.543°$

= *51°*

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