SURA'S

Sample Question Papers

Physics

Time : 2½ hours
Written Exam Marks : 70 Marks
(Sample Question Papers only for Practice)

Kind Attention to the Students

- From this year onwards, blue print system has been abolished.
- Please note that questions will be framed from IN-TEXT portions ALSO.
- Approximately 20% of the questions will be asked from IN-TEXT portions.
- These questions will be based on Reasoning and Understanding of the lessons.
- Further, Creative and Higher Order Thinking Skills questions will also be asked. It requires the students to clearly understand the lessons. So the students have to think and answer such questions.
- It is instructed that henceforth if any questions are asked from 'out of syllabus', grace marks will not be given.
- Term Test, Revision Test and Model Exam will be conducted based on the above pattern only.
- Concentrating only on the book-back questions and/or previous year questions, henceforth, may not ensure to score 100% marks.
- Also note that the answers must be written either in blue ink or in black ink. Avoid using both the colour inks to answer the questions.
- For MCQs, the answers should be written in full. Simply writing (a) or (b) etc. will not get full marks. You have to write (a) or (b) etc., along with the answer given in the options.

SURA'S SAMPLE QUESTION PAPER

11^{th} STD.

TIME ALLOWED : 2 ½ HOURS | **PHYSICS** | MAXIMUM MARKS : 70

PART - I

Note : **(i) Answer all the questions: (15 × 1 = 15)**
(ii) Choose the best answer:

1. Which of the following pairs of physical quantities have same dimension?
   (a) force and power (b) torque and energy
   (c) torque and power (d) force and torque

2. The density of a material in CGS system of units is 4 g cm^{-3} . In a system of units in which unit of length is 10 cm and unit of mass is 100 g, then the value of density of material will be
   (a) 0.04 (b) 0.4 (c) 40 (d) 400

3. Match the following fundamental forces with respect to relative strengths.

(1)	Gravitational force	(a)	1
(2)	Electromagnetic force	(b)	10^{-39}
(3)	Weak nuclear force	(c)	10^{-2}
(4)	Strong nuclear force	(d)	10^{-13}

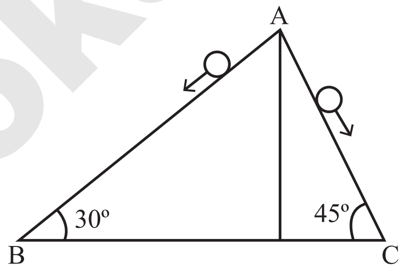
	(1)	(2)	(3)	(4)
(a)	a	d	b	c
(b)	b	c	d	a
(c)	c	d	a	b
(d)	c	a	b	d

4. If a particle has negative velocity and negative acceleration, its speed
   (a) increases (b) decreases
   (c) remains same (d) zero

5. If a particle executes uniform circular motion, choose the correct statement.
   (a) The velocity and speed are constant
   (b) The acceleration and speed are constant.
   (c) The velocity and acceleration are constant.
   (d) The speed and magnitude of acceleration are constant.

6. The length of a vector is _________
   (a) always a negative quantity
   (b) always a positive quantity
   (c) either positive or negative
   (d) denoted by 'λ'

7. A particle of mass m sliding on the smooth double inclined plane (shown in figure) will experience



   (a) greater acceleration along the path AB
   (b) greater acceleration along the path AC
   (c) same acceleration in both the paths
   (d) no acceleration in both the paths

8. An object of mass m begins to move on the plane inclined at an angle θ. The coefficient of static friction of inclined surface is μ_s. The maximum static friction experienced by the mass is
   (a) mg (b) $\mu_s mg$
   (c) $\mu_s mg \sin\theta$ (d) $\mu_s mg \cos\theta$

9. Three forces F_2, F_2 & F_3 are acting on a particle of mass ***m*** such that F_2 & F_3 are mutually perpendicular, then the particle remains stationary. If the force F_1 is now removed, then the acceleration of the particle is
   (a) $\frac{F_1}{m}$ (b) $\frac{F_2F_3}{mF}$
   (c) $\frac{F_2 - F_3}{m}$ (d) $\frac{F_2}{m}$

10. A ball of mass 1 kg and another of mass 2 kg are dropped from a tall building whose height is 80 m. After, a fall of 40 m each towards Earth, their respective kinetic energies will be in the ratio of

 (a) $\sqrt{2}:1$ (b) $1:\sqrt{2}$
 (c) 2 : 1 (d) 1 : 2

11. The potential energy of a system increases, if work is done

 (a) by the system against a conservative force
 (b) by the system against a non-conservative force
 (c) upon the system by a conservative force
 (d) upon the system by a non- conservative force

12. A bullet is fired and gets embedded in a block kept on table. If table is frictionless, then

 (a) Kinetic Energy gets conserved
 (b) Potential Energy gets conserved
 (c) Momentum conserved
 (d) both (a) and (c)

13. A particle is moving with a constant velocity along a line parallel to positive X-axis. The magnitude of its angular momentum with respect to the origin is,

 (a) zero
 (b) increasing with x
 (c) decreasing with x
 (d) remaining constant

14. Two discs of same moment of inertia rotating about their regular axis passing through center and perpendicular to the plane of disc with angular velocities ω_1 and ω_2. They are brought in to contact face to face coinciding the axis of rotation. The expression for loss of energy during this process is,

 (a) $\frac{1}{4}\,I(\omega_1-\omega_2)^2$ (b) $I(\omega_1-\omega_2)^2$
 (c) $\frac{1}{8}\,I(\omega_1-\omega_2)^2$ (d) $\frac{1}{2}\,I(\omega_1-\omega_2)^2$

15. From a disc of radius R a mass M, a circular hole of diameter R, whose rim passes through the center is cut. What is the moment of inertia of the remaining part of the disc about a perpendicular axis passing through it

 (a) $15MR^2/32$ (b) $13MR^2/32$
 (c) $11MR^2/32$ (d) $9MR^2/32$

Part - II

Answer any six questions in which question no. 21 is compulsory: (6 × 2 = 12)

16. What are the limitations of dimensional analysis?
17. Explain what is meant by Cartesian coordinate system?
18. Define velocity and speed.
19. What are inertial frames?
20. Under what condition will a car skid on a leveled circular road?
21. Write the various types of potential energy. Explain the formulae.
22. Why should the object be moved at constant velocity when we define potential energy?
23. Two identical water bottles one empty and the other filled with water are allowed to roll down an inclined plane. Which one of them reaches the bottom first? Explain your answer.
24. A rectangle block rests on a horizontal table. A horizontal force is applied on the block at a height h above the table to move the block. Does the line of action of the normal force N exerted by the table on the block depend on h?

Part - III

Answer any six questions in which question no. 30 is compulsory: (6 × 3 = 18)

25. Write the rules for determining significant figures.
26. Explain Random errors.
27. Write down the expression for angle made by resultant acceleration and radius vector in the non uniform circular motion.
28. What does the slope of 'position-time' graph represent? Which physical quantity is obtained from it?

29. State the empirical laws of static and kinetic friction.
30. Define the following.
    (a) Coefficient of restitution
    (b) Power
    (c) Law of conservation of energy.
31. What is conservative force? State how it is determined from potential energy?
32. What is the relation between torque and angular momentum?
33. Derive an expression for work done by Torque.

Part - IV

Answer all the questions. (5 × 5 = 25)

34. (a) Explain in detail the various types of errors.

(or)

(b) Discuss the relation of physics with other branches of science.

35. (a) Explain in detail the triangle law of addition.

(or)

(b) Mention important protertics of the scalar product of two vectors.

36. (a) What are concurrent forces? State Lami's theorem.

(or)

(b) Briefly explain 'rolling friction'.

37. (a) State and prove the law of conservation of energy.

(or)

(i) What does the work-kinetic energy theorem imply?

(ii) How can an object move with zero acceleration (constant velocity) when the external force is acting on the object?

38. (a) How do you distinguish between stable and unstable equilibrium?

(or)

(b) State and prove perpendicular axis theorem.

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ANSWERS

Part - I

1. (b) torque and energy
2. (c) 40
3. (b) b c d a
4. (a) increases
5. (d) The speed and magnitude of acceleration are constant.
6. (b) always a positive quantity
7. (b) greater acceleration along the path AC
8. (d) $\mu_s mg \cos\theta$
9. (a) $\frac{F_1}{m}$
10. (d) 1 : 2
11. (a) by the system against a conservative force
12. (c) Momentum conserved
13. (d) remaining constant
14. (a) $\frac{1}{4} I (\omega_1 - \omega_2)^2$
15. (b) $13MR^2/32$

Part - II

16. **Limitations of Dimensional analysis :**
    (i) This method gives no information about the dimensionless constants in the formula like 1, 2, ……..π,e, etc.
    (ii) This method cannot decide whether the given quantity is a vector or a scalar.
    (iii) This method is not suitable to derive relations involving trigonometric, exponential and logarithmic functions.
    (iv) It cannot be applied to an equation involving more than three physical quantities.
    (v) It can only check on whether a physical relation is dimensionally correct but not the correctness of the relation.
    For example using dimensional analysis, $s = ut + 1/3\ at^2$ is dimensionally correct whereas the correct relation is $s = ut + 1/2\ at^2$.

17. At any given instant of time, the frame of reference with respect to which the position of the object is described in terms of position coordinates (x, y, z) (i.e., distances of the given position of an object along the x, y, and z–axes.) is called **"Cartesian coordinate system"**.

18. **Velocity :**
    It is the rate of change of displacement. It is a velocity.
    Speed :
    It is the distance travelled in unit time. It is a speed.

19. (i) In this inertial frames an object experiences no force it moves with constant velocity or remains at rest.
    (ii) A frame of reference in which Newton's first law of motion holds good is called an inertial frame of reference.

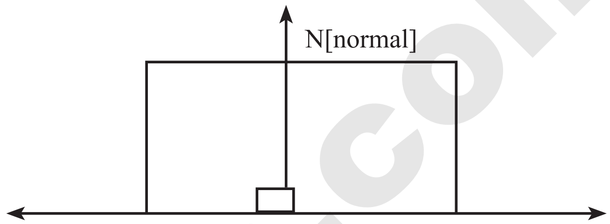
20. If the static friction is not able to provide enough centripetal force to turn, the vehicle will start to skid.
    $\mu_s < \frac{v^2}{rg}$ (skid)

21. Various types of potential energies.
    Each type is associated with a particular force. For example,
    (i) The energy possessed by the body due to gravitational force gives rise to gravitational potential energy.
    $$U = mgh$$
    (ii) The energy due to spring force and other similar forces give rise to elastic potential energy.
    $$U = \frac{1}{2}\ k\ (x_f^2 - x_i^2)$$
    (iii) The energy due to electrostatic force on charges gives rise to electrostatic potential energy.
    $$U = \frac{q_1 q_2}{4\pi \Sigma r}$$

22. (i) If the object does not move at constant velocity, then it will have different velocities at the initial and final locations.
    (ii) According to work-kinetic energy theorem, the external force will impart some extra kinetic energy.
    (iii) But we associate potential energy to the forces like gravitational force, spring force and coulomb force.
    (iv) So the external agency should not impart any kinetic energy when the object is taken from initial to final location.

23. (i) Bottle filled with water rolls, faster than the empty bottle. Due to M.I. $I = mr^2$.
(ii) When it rolls, down it possesses translational K.E. and rotational K.E.
(iii) For the empty bottle 100% of the mass of the bottle spins as the bottle rolls.
(iv) But for full bottle, much of the water in the bottle is effectively sliding down without spinning.
(v) Thus 100% of the mass of the sliding water goes into translational K.E. and full bottle have a greater speed.

24. The line of action of normal force N exerted by the table on the block does not depend on *h* because the reactionary force N exerted by the table which is directed vertically upward and passes through its centre of gravity. Since the block is in equilibrium, N=mg.
Friction is always perpendicular to the normal force N acting between the surfaces. It acts tangential to the surface of contact.



Part - III

25. (i) All non-zero digits are significant
(ii) All zeros between two non zero digits are significant
(iii) All zeros to the right of a non-zero digit but to the left of a decimal point are significant.
(iv) a) The number without a decimal point, the terminal or trailing zero(s) are not significant.
b) All zeros are significant if they come from a measurement
(v) If the number is less than 1, the zero (s) on the right of the decimal point but to left of the first non zero digit are not significant.
(vi) All zeros to the right of a decimal point and to the right of non-zero digit are significant.
(vii) The number of significant figures does not depend on the system of units used.

26. **Random errors**
(i) Random errors may arise due to random and unpredictable variations in experimental conditions like pressure, temperature, voltage supply etc.
(ii) Errors may also be due to personal errors by the observer who performs the experiment. Random errors are sometimes called "chance error".
(iii) When different readings are obtained by a person every time he repeats the experiment, personal error occurs.
(iv) For example, consider the case of the thickness of a wire measured using a screw gauge.
(v) The readings taken may be different for different trials. In this case, a large number of measurements are made and then the arithmetic mean is taken.
(vi) If n number of trial readings are taken in an experiment, and the readings are $a_1, a_2, a_3, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots a_n$. The arithmetic mean is

$$a_m = \frac{a_1 + a_2 + a_3 + \ldots\ldots\ldots\ldots an}{n}$$

$$a_m = \frac{1}{n}\sum_{i=1}^{i=n} a_i$$

Usually this arithmetic mean is taken as the best possible true value of the quantity.

27. (i) Consider a particle moving along a circular path of radius r with a variable speed v.

(ii) As the speed of the particle changes, acceleration has a tangential component, $a_t = \frac{dv}{dt} r\,\mu = \boxed{a_t = r_\alpha}$

(iii) As the direction of motion changes continuously, the acceleration has a radial component (i.e.) centripetal acceleration.

$$\therefore \boxed{a_c = \frac{v^2}{r}}$$

(iv) The resultant acceleration is obtained by vector sum of centripetal and tangential acceleration.

(v) The magnitude of this resultant acceleration is given by $a_R = \sqrt{a_t^2 + \left(\frac{v^2}{r}\right)^2}$

This resultant acceleration makes an angle θ with the radius vector.

This angle is given by $\tan\theta = \frac{a_t}{\left(\frac{v^2}{r}\right)}$

28. (i) Graphically the slope of the position-time graph will give the velocity of the particle.

(ii) At the same time, if velocity-time graph is given, the distance and displacement are determined, by calculating the area under the curve.

Velocity is given by $\frac{dx}{dt} = v$.

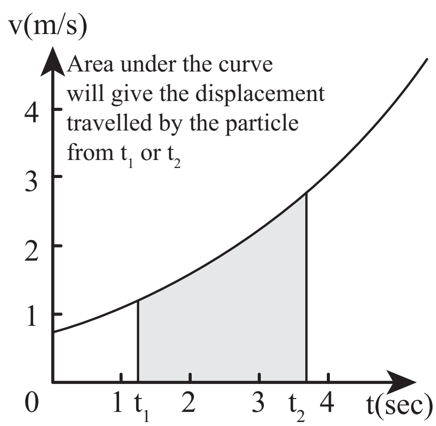
(iii) Therefore, $dx = vdt$

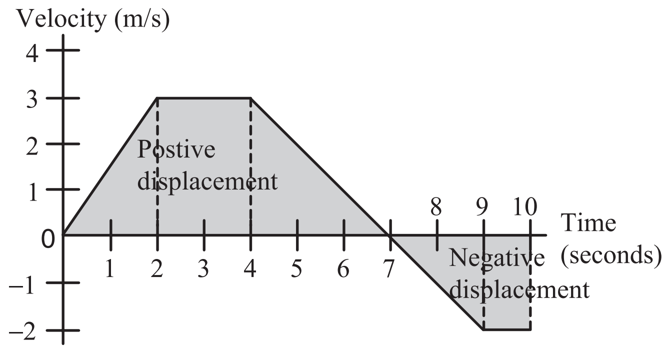
By integrating both sides, $\int_{x_1}^{x_2} dx = \int_{x_1}^{x_2} v\,dt$

Integration is equivalent to area under the given curve.

(iv) So the term $\int_{t_1}^{t_2} v\,dt$ represents the area under the curve v as a function of time.

(v) Since the left hand side of the integration represents the displacement travelled by the particle from time t_1 to t_2, the area under the velocity time graph will give the displacement of the particle.





Displacement in the velocity - time graph

(vi) If the area is negative, it means that displacement is negative, so the particle has travelled in the negative direction.

29. (i) The magnitude of static frictional force f_s satisfies the following empirical relation. $0 \leq f_s \leq \mu_s N$, where μ_s is the coefficient of static friction.

(ii) The force of static friction can taken any value from zero to $\mu_s N$.

(iii) If the object is at rest and no external force is applied on the object, the static friction acting on the object is zero ($f_s = 0$).

(iv) If the object is at rest, and there is an external force applied parallel to the surface, then the force of static friction acting on the object is exactly equal to the external force applied on the object (fs = Fext). But still the static friction f_s is less than $\mu_s N$.

(v) When object begins to slide, the static friction (f_s) acting on the object attains maximum.

(vi) The static and kinetic frictions depend on the normal force acting on the object.

(vii) The static friction does not depend upon the area of contact.

30. (a) Co-efficient of resitution is defined as the ratio of velocity of separation (relative velocity) after collision to the velocity of approach (relative velocity) before collision, i.e.,

$$e = \frac{\text{velocity of separation(after collision)}}{\text{velocity of approach (before collision)}}$$

$$= \frac{(v_2 - v_1)}{(u_1 - u_2)}$$

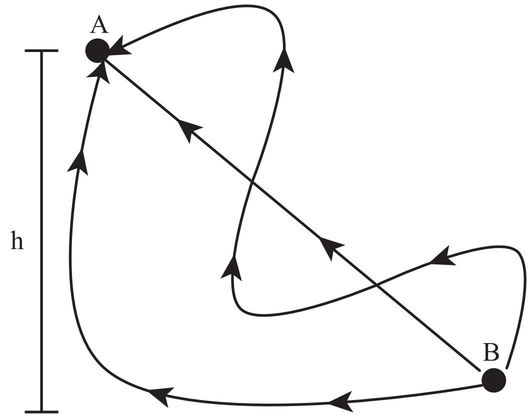
(b) Power is defined as the rate of work done or energy delivered.

$$\text{Power} = \frac{\text{work done}\,(w)}{\text{time taken}\,(t)} = \vec{F}.\vec{v}$$

(c) The law of conservation of energy states that energy can neither be created nor destroyed. It may be transformed from one form to another but the total energy of an isolated system remains constant.

31. (i) A force is said to be a conservative force if the work done by or against the force in moving the body depends only on the initial and final positions of the body and not on the nature of the path followed between the initial and final positions.

(ii) Consider an object at point A on the earth. It can be taken to another point B at a height h above the surface of the Earth by three paths as shown in Figure.



Conservative force

(iii) Whatever may be the path, the work done against the gravitational force is the same as long as the initial and final positions are the same.

(iv) This is the reason why gravitational force is a conservative force.

(v) Conservative force is equal to the negative gradient of the potential energy. In one dimensional case,

$$F_x = -\frac{dU}{dx}$$

32. (i) The expression for magnitude of angular momentum of a rigid body, L = Iω. The expression for magnitude of torque on a rigid body is, $\tau = I\alpha$.

(ii) We can further write the expression for torque as,

$$\tau = I\frac{d\omega}{dt} \because \left(\alpha = \frac{d\omega}{dt}\right) \quad ...(1)$$

where, ω is angular velocity and α is angular acceleration.

(iii) We can also write equation (1) as,

$$\tau = \frac{d(I\omega)}{dt}$$

$$\tau = \frac{dL}{dt}$$

An external torque on a rigid body fixed to an axis produces rate of change of angular momentum in the body about that axis.

33. (i) Consider a rigid body rotating about a fixed axis. A point P on the body rotating about an axis perpendicular to the plane of the page. A tangential force F is applied on the body.

(ii) It produces a small displacement ds on the body. The work done (dw) by the force is,

$$dw = F ds$$

(iii) As the distance ds, the angle of rotation $d\theta$ and radius r are related by the expression,

$$ds = r\, d\theta$$

The expression for work done now becomes,

$$dw = F\, ds; \;\; dw = F\, r\, d\theta$$

(iv) The term (Fr) is the torque τ produced by the force on the body.

$$dw = \tau d\theta$$

This expression gives the work done by the external torque τ, which acts on the body rotating about a fixed axis through an angle $d\theta$.

Part - IV

34. (a) **Types of errors :**

(i) Systematic error (ii) Random error

(iii) Gross error

(i) Systematic errors : They are reproducible inaccuracies that are consistently in the same direction. These are the errors whose causes are known. It can be minimised.

It is classified as follows :

(1) **Instrumental errors :** It arises when an instrument is not calibrated properly at the time of manufacturer. It can be corrected by choosing accurate instruments.

(2) **Imperfections in experimental technique or procedure:** It is due to the limitation in the experimental arrangement. To overcome this, necessary and proper correction is to be applied.

(3) **Personal errors :** These errors are due to individuals performing the experiment, may be due to incorrect initial setting up of the experiment or carelessness of the individual making the observation due to improper precautions.

(4) **Errors due to external causes :** The change in the external conditions during an experiment can cause error in measurement. For example, changes in temperature, humidity, or pressure during measurements may affect the result of the measurement.

(5) **Least count error :** Least count is the smallest value that can be measured by the measuring instrument, and the error due to this measurement is least count error.

(ii) Random error :

(1) It arises due to random and unpredictable variations in experimental conditions like pressure, temperature, voltage supply etc.

(2) It also arises due to personal errors by the observer. It is sometimes called 'chance errors'.

(3) It can be minimised by repeating the observations a large number of times and taking the arithmetic mean of all the observations.

(iii) Gross error :

(1) The error caused due to the shear carelessness of an observer is called gross error.

(2) It can be minimized only when an observer is careful and mentally alert.

(or)

34. (b) Physics is the most fundamental branch of science. It has played a key role in the development of all branches of sciences.

Physics in relation to mathematics

- Physics is a quantitative science. Mathematics provides the necessary signs and tools which the physicist use.
- It has played an important role in the development of theoretical physics.
- Had newton not invented calculus, he would not have been able to discover the universal law of gravitation.

Physics in relation to chemistry:

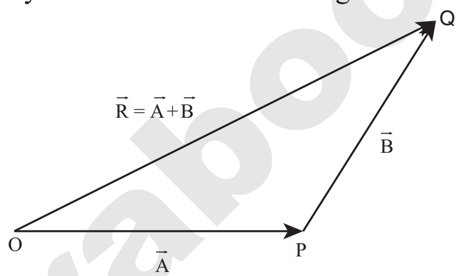
- In physics, we study the structure of atom, radio activity, X-ray diffraction, etc.
- Such studies have enabled chemists to arrange elements in the periodic table on the basis of their atomic numbers.
- This has further helped to know the nature of valency and chemical bonding and to understand the complex chmical structures.

Physics in relation to biology:

- The developments in life sciences a great deal to physics.
- Optical microscopes are extensively used in the study of biology.
- With the help of an electron microscope, one can study the structure of cell.
- The X-rays and neutron diffraction techniques have helped in understanding the structure of nucleic acids, which helped to control vital life process.
- Radio isotopes are used in radiation therapy for the cure of deadly diseases like cancer.

35. (a) (i) Represent the vectors $\vec{A}$ and $\vec{B}$ by the two adjacent sides of a triangle taken in the same order.

(ii) Then the resultant is given by the third side of the triangle taken in the opposite order.



Triangle law of addition

(iii) The head of the first vector $\vec{A}$ is connected to the tail of the second vector $\vec{B}$.

(iv) Let θ be the angle between $\vec{A}$ and $\vec{B}$. Then $\vec{R}$ is the resultant vector connecting the tail of the first vector $\vec{A}$ to the head of the second vector $\vec{B}$.

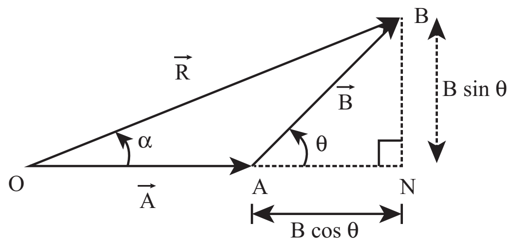
(v) The magnitude of $\vec{R}$ (resultant) is given geometrically by the length of $\vec{R}$ (OQ) and the direction of the resultant vector is the angle between $\vec{R}$ and $\vec{A}$.

(vi) Thus we write $\vec{R} = \vec{A} + \vec{B}$

$\because \overrightarrow{OQ} = \overrightarrow{OP} + \overrightarrow{PQ}$

Magnitude of resultant vector

Consider the triangle ABN, which is obtained by extending the side OA to ON. ABN is a right angled triangle.



Resultant vector and its direction by triangle law of addition

$\cos\theta = \frac{AN}{B}$ $\therefore AN = B\cos\theta$ and

$\sin\theta = \frac{BN}{B}$ $\therefore BN = B\sin\theta$

For ΔOBN, we have $OB^2 + ON^2 + BN^2$

$\Rightarrow R^2 = (A + B\cos\theta)^2 + (B\sin\theta)^2$

$\Rightarrow R^2 = A^2 + B^2\cos^2\theta + 2AB\cos\theta + B^2\sin^2\theta$

$\Rightarrow R^2 = A^2 + B^2(\cos^2\theta + \sin^2\theta) + 2AB\cos\theta$

$\Rightarrow R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$

which is the magnitude of the resultant of $\vec{A}$ and $\vec{B}$.

Direction of resultant vectors: If θ is the angle between $\vec{A}$ and $\vec{B}$, then

$$\left|\vec{A} + \vec{B}\right| = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

If $\vec{R}$ makes an angle α with $\vec{A}$ then in ΔOBN,

$$\tan\alpha = \frac{BN}{ON} = \frac{BN}{OA + AN}$$

$$\tan\alpha = \left(\frac{B\sin\theta}{A + B\cos\theta}\right)$$

$$\Rightarrow \alpha = \tan^{-1}\left(\frac{B\sin\theta}{A + B\cos\theta}\right)$$

(or)

35. (b) (i) The product quantity $\vec{A} \cdot \vec{B}$ is always a scalar. It is positive if the angle between the vectors is acute (i.e., < 90°) and negative if the angle between them is obtuse (i.e. 90°<θ< 180°).

(ii) The scalar product is commutative, i.e. $\vec{A} \cdot \vec{B} = \vec{B} \cdot \vec{A}$

(iii) The vectors obey distributive law i.e. $\vec{A} \cdot (\vec{B} + \vec{C}) = \vec{A} \cdot \vec{B} + \vec{A} \cdot \vec{C}$

(iv) The angle between the vectors $\theta = \cos^{-1}\left[\frac{\vec{A} \cdot \vec{B}}{AB}\right]$

(v) The scalar product of two vectors will be maximum when $\cos\theta = 1$, i.e. $\theta = 0°$, i.e., when the vectors are parallel;

$(\vec{A} \cdot \vec{B})_{max} = AB$

(vi) The scalar product of two vectors will be minimum, when $\cos\theta = -1$, i.e. $\theta = 180°$

$(\vec{A} \cdot \vec{B})_{min} = -AB$, when the vectors are anti-parallel.

(vii) If two vectors $\vec{A}$ and $\vec{B}$ are perpendicular to each other then their scalar product $\vec{A}\cdot\vec{B} = 0$, because cos 90°= 0. Then the vectors $\vec{A}$ and $\vec{B}$ are said to be mutually orthogonal.

(viii) The scalar product of a vector with itself is termed as self–dot product and is given by $(\vec{A})^2 = \vec{A}\cdot\vec{A} = AA\cos\theta = A^2$.

Here angle $\theta = 0°$

The magnitude or norm of the vector

$\vec{A}$ is $|\vec{A}| = A = \sqrt{\vec{A}.\vec{A}}$

(ix) In case of a unit vector $\hat{n}$

$\hat{n}.\hat{n} = 1 \times 1 \times \cos 0 = 1$. For example,

$\hat{i}\cdot\hat{i} = \hat{j}\cdot\hat{j} = \hat{k}\cdot\hat{k} = 1.$

(x) In the case of orthogonal unit vectors $\hat{i}$, $\hat{j}$ and $\hat{k}$,

$\hat{i}.\hat{j} = \hat{j}.\hat{k} = \hat{k}.\hat{i} = 1.1 \cos 90° = 0$

(xi) In terms of components the scalar product of $\vec{A}$ and $\vec{B}$ can be written as

$\vec{A}.\vec{B} = (A_x\hat{i} + A_y\hat{j} + A_z\hat{k}).(B_x\hat{i} + B_y\hat{j} + B_z\hat{k})$

$= A_xB_x + A_yB_y + A_zB_z$, with all other terms zero.

The magnitude of vector $|\vec{A}|$ is given by $|\vec{A}| = A = \sqrt{A_x^2 + A_y^2 + A_z^2}$.

36. (a) (i) A collection of forces is said to be concurrent, if the lines of forces act at a common point.

(ii) If a system of three concurrent and coplanar forces is in equilibrium, then Lami's theorem states that the magnitude of each force of the system is proportional to sine of the angle between the other two forces.

(iii) The constant of proportionality is same for all three forces.

$$\frac{|\vec{F}_1|}{\sin\alpha} = \frac{|\vec{F}_2|}{\sin\gamma} = \frac{|\vec{F}_3|}{\sin\beta}$$

Example:

A baby is playing in a swing which is hanging with the help of two identical chains is at rest. Identify the forces acting on the baby. Apply Lami's theorem and find out the tension acting on the chain.

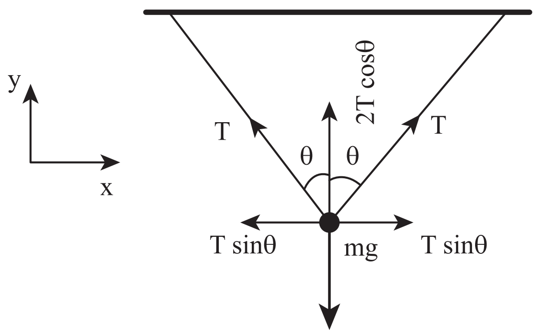
Solution:

The baby and the chains are modeled as a particle hung by two strings. There are three forces acting on the baby.

(i) Downward gravitational force along negative y direction (mg)

(ii) Tension (T) along the two strings

These three forces are coplanar as well as concurrent as shown in the following figure.



By using Lami's theorem

$$\frac{T}{\sin(180-\theta)} = \frac{T}{\sin(180-\theta)} = \frac{mg}{\sin(2\theta)}$$

Since $\sin(180 - \theta) = \sin\theta$ and

$\sin(2\theta) = 2\sin\theta\cos\theta$.

We get $\frac{T}{\sin\theta} = \frac{mg}{2\sin\theta\cos\theta}$

From this, the tension on each string is $T = \frac{mg}{2\cos\theta}$.

(or)

36. (b) (i) One of the important applications is suitcases with rolling on coasters. Rolling wheels makes it easier than carrying luggage.

(ii) When an object moves on a surface, essentially it is sliding on it. But wheels move on the surface through rolling motion.

(iii) In **rolling motion** when a wheel moves on a surface, **the point of contact with surface is always at rest**.

(iv) **Since the point of contact is at rest**, there is no relative motion between the wheel and surface. Hence the **frictional force is very less**. At the same time if an object moves **without a wheel**, there is a relative motion between the object and the surface.

(v) As a result **frictional force is larger**. This makes it **difficult to move the object**.

(vi) Ideally in pure rolling, motion of the point of contact with the surface should be at rest, but in practice it is not so.

(vii) Due to the elastic nature of the surface at the point of contact there will be some deformation on the object at this point on the wheel or surface.

(viii) **Due to this deformation, there will be minimal friction between wheel and surface. It is called 'rolling friction'**. In fact, 'rolling friction' is much smaller than kinetic friction.

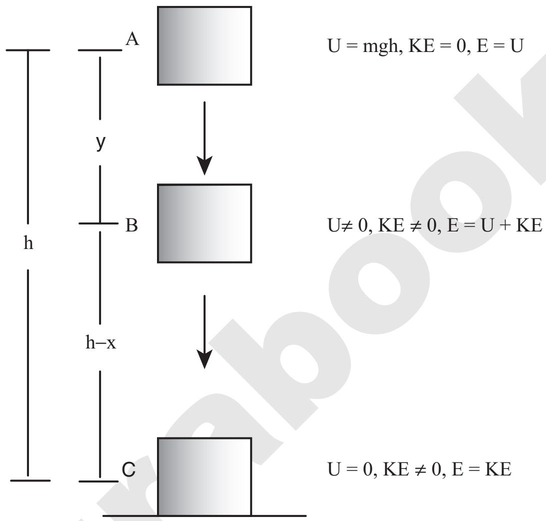
37. (a) (i) When an object is thrown upwards its kinetic energy goes on decreasing and consequently its potential energy keeps increasing (neglecting air resistance).

(ii) When it reaches the highest point its energy is completely potential. Similarly, when the object falls back from a height its kinetic energy increases whereas its potential energy decreases.

(iii) When it touches the ground its energy is completely kinetic. At the intermediate points the energy is both kinetic and potential as shown in Figure.

(iv) When the body reaches the ground the kinetic energy is completely dissipated into some other form of energy like sound, heat, light and deformation of the body etc.

(v) In this example the energy transformation takes place at every point. The sum of kinetic energy and potential energy i.e., the total mechanical energy always remains constant, implying that the total energy is conserved. This is stated as the law of conservation of energy.



(vi) The law of conservation of energy states that energy can neither be created nor destroyed. It may be transformed from one form to another but the total energy of an isolated system remains constant.

(vii) The figure Illustrates that, if an object starts from rest at height h, the total energy is purely potential energy (U=mgh) and the kinetic energy (KE) is zero at h. When the object falls at some distance y, the potential energy and the kinetic energy are not zero whereas, the total energy remains same as measured at height h. When the object is about to touch the ground, the potential energy is zero and total energy is purely kinetic.

(or)

37. (i) **It implies the following.**

(i) If the work done by the force on the body is positive then its kinetic energy increases.

(ii) If the work done by the force on the body is negative then its kinetic energy decreases.

(iii) If there is no work done by the force on the body then there is no change in its kinetic energy, which means that the body has moved at constant speed provided its mass remains constant.

(ii) (i) It is possible when there is another force which acts exactly opposite to the external applied force.

(ii) They both cancel each other and the resulting net force becomes zero, hence the object moves with zero acceleration.

38. (a) Stable equilibrium

Stable equilibrium	Unstable equilibrium
Linear momentum and angular momentum are zero.	Linear momentum and angular momentum are zero.
The body tries to come back to equilibrium if slightly disturbed and released.	The body cannot come back to equilibrium if slightly disturbed and released.
The center of mass of the body shifts slightly higher if disturbed from equilibrium.	The center of mass of the body shifts slightly lower if disturbed from equilibrium.
Potential energy of the body is minimum and it increases if disturbed..	Potential energy of the body is not minimum and it decreases if disturbed.

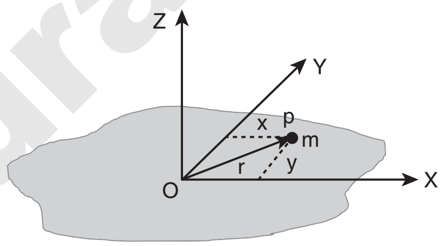
(or)

38. (b) (i) The theorem states that the moment of inertia of a plane laminar body about an axis perpendicular to its plane is equal to the sum of moments of inertia about two perpendicular axes lying in the plane of the body such that all the three axes are mutually perpendicular and have a common point.

(ii) Let the X and Y-axes lie in the plane and Z-axis perpendicular to the plane of the laminar object. If the moments of inertia of the the body about X and Y-axes are I_x and I_y respectively and I_z is the moment of inertia about Z-axis, then the perpendicular axis theorem could be expressed as,

$$I_z = I_x + I_y$$

(iii) To prove this theorem, let us consider a plane laminar object of negligible thickness on which lies the origin (O). The X and Y-axes lie on the plane and Z-axis is perpendicular to it as shown in Figure. The lamina is considered to be made up of a large number of particles of mass m. Let us choose one such particle at a point P which has coordinates (x, y) at a distance r from O.



Perpendicular axis theorem

(iv) The moment of inertia of the particle about Z-axis is, mr^2. The summation of the above expression gives the moment of inertia of the entire lamina about Z-axis as, $I_z = \sum mr^2$

Here, $r^2 = x^2 + y^2$

Then, $I_z = \sum m(x^2 + y^2)$

$I_z = \sum mx^2 + \sum my^2$

(v) In the above expression, the term $\sum mx^2$ is the moment of inertia of the body about the Y-axis and similarly the term $\sum my^2$ is the moment of inertia about X-axis. Thus,

$I_x = \sum my^2$ and $I_y = \sum mx^2$

Substituting in the equation for I_z gives,

$I_z = I_x + I_y$

Thus, the perpendicular axis theorem is proved.

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