

2025

- (i) A body is acted upon by two equal and opposite forces, that are NOT along the same straight line. The body will:
 - (a) remain stationary

- (b) have only rotational motion
- (c) have only rectilinear motion
- (d) have both rectilinear and rotational motion

Answer (b)

- (iii) What is the correct energy transformation during burning of a candle?
 - (a) heat → kinetic + potential
 - (b) heat → chemical + light
 - (c) chemical → heat + light
 - (d) mechanical → chemical + heat

Answer : (c)

- (vi) For a lever, a graph is plotted with load on Y-axis and effort on X-axis. Which of the following represents the slope of the graph?
 - (a) Mechanical advantage
 - (b) Velocity ratio
 - (c) 1 / Velocity ratio
 - (d) 1 / Mechanical advantage

Answer (a)

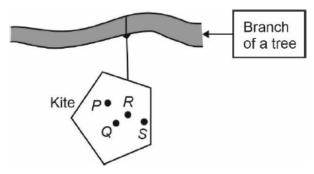


Question 2

- (i) Complete the following by choosing the correct answers from the bracket: [6]

Answer: away from the centre

(ii) A **non-uniform** kite is hanging freely from the branch of a tree as shown. Study the figure and answer the following:



(a) Fill in the blank

____(P, Q, R or S) is the most probable position of its centre of gravity.

(b) Support your answer to (a) with a reason.

(a)

R is the most probable position of its centre of gravity.

(b)

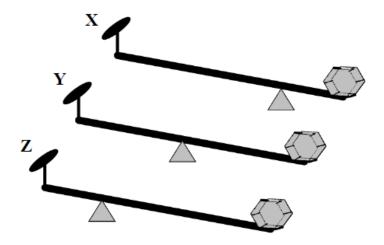
Reason:

The centre of gravity of a freely suspended body always lies vertically below the point of suspension. Since the kite is hanging freely and remains in equilibrium, point R lies directly below the string (suspension), making it the most probable position of the centre of gravity.



Question 6

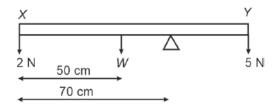
- (i) Akash takes a uniform meter scale and suspends a weight of 2 N at one end 'X' [3] and a weight of 5 N on the other end 'Y'. He then balances the ruler horizontally on a knife edge placed at 70 cm from X. Draw a diagram of the arrangement and calculate the weight of the ruler.
- (ii) Three levers **X**, **Y**, **Z** of **equal lengths** are shown in the diagram. [3]



- (a) Which class of lever do these belong to?
- (b) Among these (X, Y or Z) which one will give the maximum mechanical



Sol. (i)



[1]

Because the ruler is balanced, the net torque acting on it must be zero. [1]

Net torque = $2 \times 70 + W \times (70 - 50) - 5 \times (30) = 0$

$$W \times 20 = 150 - 140$$

$$W = 0.5 \text{ N}$$

[1]

(i) Calculation Based on Moment of Forces

Given:

- Weight at X = 2 N
- Weight at Y = 5 N
- Fulcrum is placed at 70 cm from X
- Length of scale = 100 cm (since it's a meter scale)
- Uniform scale → weight acts at 50 cm mark

Let the weight of the ruler be W N.

Let's take the moment about the fulcrum (at 70 cm):

Distances from the fulcrum:

- Distance of 2 N from fulcrum = 70 0 = 70 cm = 0.70 m
- Distance of 5 N from fulcrum = 100 70 = 30 cm = 0.30 m
- Distance of weight of ruler (acts at 50 cm) from fulcrum = 70 50 = 20 cm = 0.20 m

Take clockwise moment = anticlockwise moment:

Clockwise moment = $5 \times 0.30 = 1.5 \, \text{Nm}$



Equating moments:

$$1.4 + 0.2W = 1.5 \Rightarrow 0.2W = 0.1 \Rightarrow W = \frac{0.1}{0.2} = 0.5 \,\mathrm{N}$$

Answer: The weight of the ruler is 0.5 N.

(ii) Lever Classification and MA

(a) Class of Levers:

- X: Effort-Fulcrum-Load → Class I lever
- Y: Fulcrum–Effort–Load → Class III lever
- Z: Fulcrum-Load-Effort → Class II lever

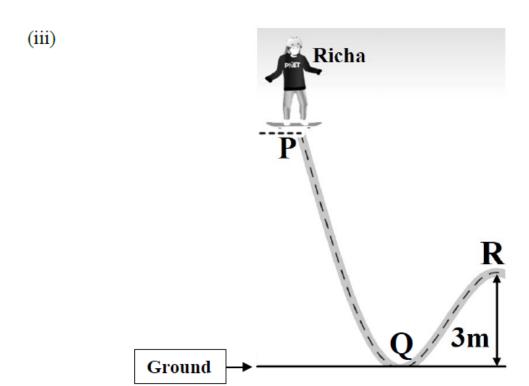
Answer:

- X = Class I
- Y = Class III
- Z = Class II

(b) Maximum Mechanical Advantage (MA):

- Class II levers always have MA > 1 (load is between fulcrum and effort)
- Among X, Y, and $Z \rightarrow Z$ (Class II) provides the maximum mechanical advantage.
- Answer: Z will give the maximum mechanical advantage.





Richa weighing 40 kgf leaves point $\bf P$ on her skateboard and reaches point $\bf Q$ on the ground with velocity 10 ms⁻¹. Calculate:

- (a) the kinetic energy of Richa at point Q.
- (b) the vertical height of point **P** above the ground. (Use g as 10 m/s² and neglect friction)
- (c) the kinetic energy of Richa at point **R.** (While moving from **Q** to **R**, she loses 500 J of energy against friction.)



Given:

- Weight of Richa = 40 kgf
- Velocity at point Q = 10 m/s
- Height of point R = 3 m
- Energy lost between Q and R = 500 J
- $g = 10 \,\mathrm{m/s^2}$

Since weight $W=40\,\mathrm{kgf}=40\times10=400\,\mathrm{N}$

And mass $m=rac{W}{g}=rac{400}{10}=40\,\mathrm{kg}$

(a) Kinetic energy of Richa at point Q

 $ext{KE}_Q = rac{1}{2} m v^2 = rac{1}{2} imes 40 imes (10)^2 = 2000 \, ext{J}$

Answer: 2000 J

(b) Height of point P above ground

At point P, all energy is potential energy.

At point Q, all energy is kinetic energy.





Using conservation of energy (no friction):

$$PE_P = KE_Q = 2000 J$$

$$\mathrm{PE}_P = mgh \Rightarrow 2000 = 40 imes 10 imes h \Rightarrow h = rac{2000}{400} = 5\,\mathrm{m}$$

Answer: 5 m

(c) Kinetic energy of Richa at point R

From Q to R:

Gains potential energy:

$$PE_R = mgh = 40 \times 10 \times 3 = 1200 \text{ J}$$

Loses 500 J to friction.

Initial energy at Q = 2000 J

Energy at R = KE + PE = 2000 - 500 = 1500 J

So,

$$KE_R = 1500 - 1200 = 300 \text{ J}$$





Final Answers:

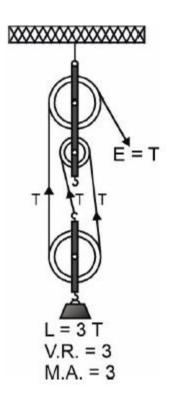
(a) Kinetic Energy at Q: 2000 J

(b) Height of P: 5 m

(c) Kinetic Energy at R: 300 J

Question 7

Draw a block and tackle system of pulleys with **velocity ratio equal to 3**. (i) [3]





2024

Question 1

Choose the correct answers to the questions from the given options.

(Do not copy the questions, write the correct answers only.)

- (i) When a bell fixed on a cycle rings, then the energy conversion that takes place is:
 - (a) gravitational potential energy to sound energy
 - (b) kinetic energy to sound energy
 - (c) sound energy to electrical energy
 - (d) sound energy to mechanical energy

The question asks about the energy conversion that occurs when a bell fixed on a cycle rings.

The correct answer is:

(b) kinetic energy to sound energy

Explanation:

When you press or flick the bell, you apply mechanical force, which gives the internal components of the bell **kinetic energy**. This kinetic energy causes the bell to vibrate, producing **sound energy**.

So, the energy conversion is:

Kinetic Energy → Sound Energy.

- (ii) A door lock is opened by turning the lever (handle) of length 0.2 m. If the moment of force produced is 1 Nm, then the minimum force required is:
 - (a) 5 N
 - (b) 10 N
 - (c) 20 N
 - (d) 0.2 N



To solve this, we use the formula for moment of force (torque):

Moment (Torque) = $Force \times Perpendicular distance (length of lever)$

Given:

- Moment = 1 Nm
- Length of lever = 0.2 m

Let the force be F. So:

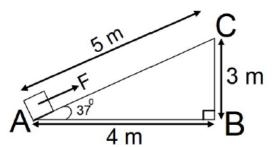
$$1 = F \times 0.2$$

Solving for **F**:

$$F = \frac{1}{0.2} = 5 \text{ N}$$

Correct answer: (a) 5 N

- (iii) A force 'F' moves a load from A to C as shown in the figure below. For the calculation of the work done, which of these lengths would you use as the displacement?
 - (a) 3m
 - (b) 4m
 - (c) 5m
 - (d) 7m





To determine displacement for work done, we need to consider the component of displacement in the direction of the applied force.

In the image:

- The force F is applied horizontally.
- Displacement is along the diagonal AC = 5 m.
- The angle between force and displacement is 37°.

The formula for work done is:

Work = Force
$$\times$$
 displacement $\times \cos(\theta)$

Where:

- Displacement = AC = 5 m
- $\theta = 37^{\circ}$
- $\cos(37^\circ) \approx 0.8$

So, the component of displacement in the direction of the force is:

$$5 \times \cos(37^\circ) = 5 \times 0.8 = 4 \text{ m}$$

Correct answer: (b) 4 m

Explanation: Since the force acts horizontally, only the **horizontal component** of the displacement (i.e., **AB** = **4 m**) is effective for calculating work.

- (vii) Which of the following is a class III lever?
 - (a) Pair of scissors
 - (b) Wheelbarrow
 - (c) Crowbar
 - (d) Human forearm



In a class III lever, the order of components is:

Fulcrum — Effort — Load

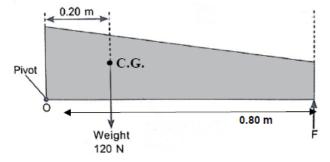
The effort is applied between the fulcrum and the load.

Examples:

- Human forearm: The elbow is the fulcrum, the biceps apply the effort in the middle, and the hand holds
 the load.
- Correct answer: (d) Human forearm
- (ii) Fill in the blanks: [2]
 - (a) When a stone tied to a string is rotated in a horizontal plane, the tension in the string provides ______ force necessary for circular motion.
 - (b) Work done by this force at any instant is _____.

For comparison:

- (a) Pair of scissors Class I lever (Fulcrum between effort and load)
- (b) Wheelbarrow Class II lever (Load between fulcrum and effort)
- (c) Crowbar Usually Class I or II depending on how it's used.
- (iii) A non uniform beam of weight 120 N pivoted at one end is shown in the diagram below.
 [2] Calculate the value of F to keep the beam in equilibrium.





Given:

- Weight of the beam = 120 N
- Distance from pivot to center of gravity (C.G.) = $0.20 \, \mathrm{m}$
- Distance from pivot to the point of application of force $F = 0.80 \,\mathrm{m}$

Step-by-step:

Moment due to the weight (anticlockwise):

$$Moment = 120 \times 0.20 = 24\,Nm$$

Moment due to F (clockwise):

$$\mathrm{Moment} = F \times 0.80$$

Equating the moments:

$$F \times 0.80 = 24$$

$$F = \frac{24}{0.80} = 30\,\mathrm{N}$$

$$F=30\,\mathrm{N}$$



2023

Question 1

Choose the correct answers to the questions from the given options.

(Do not copy the questions, write the correct answers only.)

- (i) Clockwise moment produced by a force about a fulcrum is considered to be:
 - (a) Positive
 - (b) Negative
 - (c) Zero
 - (d) None of these

Correct answer: (b) Negative

In physics, by convention:

- Clockwise moments are taken as negative
- Anticlockwise moments are taken as positive

This convention is commonly followed in problems involving torques and moments.

- (ii) When the speed of a moving object is *doubled*, then its *kinetic energy*:
 - (a) remains the same
 - (b) decreases
 - (c) is doubled
 - (d) becomes four times



Correct answer: (d) becomes four times

Explanation:

Kinetic energy is given by the formula:

$$\text{K.E.} = \frac{1}{2}mv^2$$

If the speed v is **doubled**, then:

New K.E.
$$=\frac{1}{2}m(2v)^2=\frac{1}{2}m\cdot 4v^2=4\cdot \text{Original K.E.}$$

So, kinetic energy becomes four times.

- The energy conversion in a washing machine is from (iii)
 - magnetic to electrical (a)
 - (b) electrical to mechanical
 - (c) electrical to magnetic
 - (d) magnetic to electrical

Correct answer: (b) electrical to mechanical

Explanation:

In a washing machine:

- Electrical energy is supplied to the motor.
- The motor converts it into **mechanical energy** to rotate the drum and agitate the clothes.

So, the energy conversion is electrical to mechanical.

(b) Name a single pulley in which displacement of load and effort is not the same.



Answer: Single movable pulley

Explanation:

In a single movable pulley, the effort moves twice the distance compared to the load.

This is because the load is supported by two segments of the rope, so pulling the rope by 2 meters raises the load by only 1 meter.

(c) State one advantage of this pulley.

Advantage of a single movable pulley:

It reduces the effort needed to lift a load -

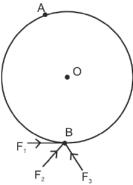
The mechanical advantage is greater than 1, which means less force is required to lift a heavy object compared to lifting it directly.

- (ii) (a) What is the position of centre of gravity of a triangular lamina? [2]
 - (b) When this triangular lamina is suspended freely from any one vertex, what is the moment of force produced by its own weight in its rest position?
- (a) The centre of gravity of a triangular lamina is at the point of intersection of its medians. It is located at a point that is one-third the distance from the base to the opposite vertex.
- (b) When the triangular lamina is suspended freely from any one vertex, the line of action of its weight passes through the centre of gravity and the point of suspension.

Hence, in its rest position, the **moment of force is zero** because the weight acts vertically downward through the point of suspension.



(iii) The diagram shows wheel O pivoted at point A. Three equal forces F₁, F₂ and F₃ [2] act at point B on the wheel.



- (a) Which force will produce maximum moment about A?
- (b) Give a reason for your answer in (a).
- (a) The force that will produce the maximum moment about point A is:



(b) Reason:

Moment (torque) is given by:

 $Moment = Force \times Perpendicular distance from the pivot$

- F_1 is perpendicular to line AB, so its perpendicular distance from point A is maximum.
- ullet F_2 and F_3 are angled and have less effective perpendicular distance.

Therefore, F_1 produces the maximum moment.

- (iv) (a) What should be the *angle* between the direction of force and the direction of displacement, for work to be negative?
 - (b) Name the physical quantity obtained using the formula $\frac{U}{h}$, where U is the potential energy and h is the height.



(a) The angle between the direction of force and displacement for work to be negative is:

→ 180°

(b) The physical quantity obtained using the formula $rac{U}{h}$, where U is potential energy and h is height, is:

👉 Weight

(or more specifically, **gravitational force**, since $U=mgh\Rightarrow \frac{U}{h}=mg$)

(v) Calculate the power spent by a crane while lifting a load of mass 2000 kg, at velocity [2] of 1.5 ms⁻¹. (g = 10 ms⁻²)

To calculate the **power spent** by the crane, use the formula:

$$Power = Force \times Velocity$$

Given:

- Mass $m=2000\,\mathrm{kg}$
- Velocity $v=1.5\,\mathrm{m/s}$
- ullet Gravitational acceleration $g=10\,\mathrm{m/s}^2$
- ullet Force required to lift = Weight = $mg = 2000 imes 10 = 20000 \, \mathrm{N}$

Calculation:

Power =
$$20000 \times 1.5 = 30000 \,\mathrm{W} = 30 \,\mathrm{kW}$$

Final Answer:

 $30\,\mathrm{kW}$



Question 6

(i) A block and tackle system of pulleys has velocity ratio 4.

[3]

- (a) Draw a labelled diagram of the system indicating clearly, the direction of the load and the effort.
- (b) What is the value of the mechanical advantage of the given pulley system if it is an ideal pulley system?

(a) Labelled Diagram:

A block and tackle system with velocity ratio (V.R.) = 4 means there are 4 pulleys — typically 2 in the upper block (fixed) and 2 in the lower block (movable).

Here's a textual representation of the setup:

- Effort is applied downward on the rope.
- Load is lifted upward.
- · All pulleys are connected via a continuous rope, wound alternately through fixed and movable pulleys.

(b) Mechanical Advantage (M.A.) of an ideal pulley system:

In an ideal system,

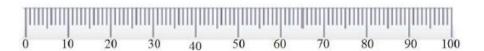
Mechanical Advantage (M.A.) = Velocity Ratio (V.R.)

So,

$$M.A. = 4$$



- (ii) A metre scale of weight 50 gf can be balanced at 40 cm mark without any weight [3] suspended on it.
 - (a) If this ruler is cut at its centre then state which part [0 to 50 cm or 50 to 100 cm] of the ruler will weigh more than 25 gf.



(b) What minimum weight placed on this metre ruler can balance this ruler when it is pivoted at its centre?

Let's go through each part step by step.

Given:

- A metre scale (100 cm long) weighs 50 gf.
- It can be **balanced at 40 cm mark**, meaning its **center of gravity is at 40 cm**, not at 50 cm (which would be the midpoint if the ruler was uniform).
- This means the mass is unevenly distributed, with more mass toward the 0 to 40 cm side.
- (a) If this ruler is cut at its centre, then state which part $[0\ to\ 50\ cm\ or\ 50\ to\ 100\ cm]$ of the ruler will weigh more than 25 gf.

Since:

- The center of mass is at 40 cm,
- · And the ruler is cut at 50 cm,

This implies:

- The [0 to 50 cm] portion includes the center of gravity (40 cm is in this half),
- Therefore, more weight lies in the [0 to 50 cm] half.

So, [0 to 50 cm] will weigh more than 25 gf, and [50 to 100 cm] will weigh less than 25 gf.



Answer: [0 to 50 cm]

(b) What minimum weight placed on this metre ruler can balance this ruler when it is pivoted at its centre?

Let's denote:

- The mass of the ruler = 50 gf
- The center of gravity = 40 cm
- The pivot point (centre of the ruler) = 50 cm

To balance the ruler about its center, we need to **add a counterweight** on the right side so that **clockwise moment** = **anticlockwise moment** about the pivot at 50 cm.

Step 1: Calculate moment due to ruler's own weight:

- Distance from center of mass (40 cm) to pivot (50 cm) = 10 cm
- Moment due to ruler = $50 \,\mathrm{gf} \times 10 \,\mathrm{cm} = 500 \,\mathrm{gf} \setminus \mathrm{cdotpcm}$ (anticlockwise)

Step 2: Let a weight W gf be placed at the right end (e.g., at 100 cm) to balance it.

- Distance from pivot (50 cm) to 100 cm = 50 cm
- Moment due to weight = $W \times 50 \, \mathrm{cm}$ (clockwise)

Equating moments:

$$W \times 50 = 500$$

 $W = \frac{500}{50} = 10 \,\mathrm{gf}$

✓ Minimum weight required = 10 gf

Final Answers:

• (a): [0 to 50 cm]

(b): 10 gf



- A car of mass 120 kg is moving at a speed 18 km/h and it accelerates to attain a (iii) [4] speed of 54 km/h in 5 seconds. Calculate:
 - (a) the work done by the engine.
 - (b) the power of the engine.

Given:

- Mass of the car $m=120\,\mathrm{kg}$
- $\begin{array}{ll} \bullet & \text{Initial speed } u = 18\,\mathrm{km/h} = \frac{18 \times 1000}{3600} = 5\,\mathrm{m/s} \\ \bullet & \text{Final speed } v = 54\,\mathrm{km/h} = \frac{54 \times 1000}{3600} = 15\,\mathrm{m/s} \end{array}$
- Time taken $t = 5 \, \mathrm{s}$
- (a) Work done by the engine

Work done = Change in kinetic energy

$$ext{K.E.} = rac{1}{2}mv^2 - rac{1}{2}mu^2 \ = rac{1}{2} imes 120 imes (15^2 - 5^2) = 60 imes (225 - 25) = 60 imes 200 = 12,000\, ext{J}$$

- Answer (a): Work done = 12,000 J
- (b) Power of the engine

$$Power = \frac{Work \ done}{Time} = \frac{12,000}{5} = 2,400 \, W$$

Answer (b): Power = 2400 W or 2.4 kW

Final Answers:

- (a): 12,000 J
- **(b)**: 2,400 W (or 2.4 kW)



- (iv) Meera chose to use a block and tackle system of '9' pulleys instead of a single movable pulley to lift a heavy load.
 - (a) What is the advantage of using a block and tackle system over a single movable pulley?
 - (b) Why should she connect more number of pulleys in the upper fixed block?
 - (a) What is the advantage of using a block and tackle system over a single movable pulley?

A **block and tackle system** offers a **higher mechanical advantage** compared to a single movable pulley. This means:

Less effort is required to lift a heavy load because the total load is distributed among multiple pulleys, making lifting easier.

(b) Why should she connect more number of pulleys in the upper fixed block?

In a block and tackle system:

- The number of pulleys in the upper fixed block affects efficiency and load distribution.
 - Connecting more pulleys in the upper fixed block helps balance the system, reduces the strain on the movable block, and allows smoother lifting by reducing friction and distributing the load more evenly.

Final Answers:

- (a): It provides a higher mechanical advantage, so less effort is needed to lift the load.
- (b): To distribute the load better, reduce strain on the system, and improve efficiency.



(v) Sumit does 600 J of work in 10 min and Amit does 300 J of work in 20 min. Calculate [2]
 the ratio of the powers delivered by them.

We are asked to calculate the ratio of powers delivered by Sumit and Amit.

Given:

Sumit:

Work done = 600 J

Time = 10 min = $10 \times 60 = 600$ s

Amit:

Work done = 300 J

Time = 20 min = $20 \times 60 = 1200$ s

Formula for Power:

$$Power = \frac{Work \ done}{Time \ taken}$$

Power by Sumit:

$$\frac{600}{600} = 1 \, W$$

Power by Amit:

$$\frac{300}{1200} = 0.25 \,\mathrm{W}$$



Ratio of powers (Sumit: Amit):

$$\frac{1}{0.25} = 4:1$$

✓ Final Answer:

The ratio of the powers delivered by Sumit and Amit is 4:1.

Question 6

(i) (a) Define Centre of Gravity.

[3]

- (b) A hollow ice cream cone has height 6 cm.
 - 1. Where is the position of its centre of gravity from the broad base?
 - Will its position change when it is filled completely with honey? Write Yes
 or No.



(i) (a) Define Centre of Gravity

The **centre of gravity** of a body is the point at which the **entire weight** of the body appears to act, irrespective of the orientation of the body.

(i) (b)

1. Where is the position of its centre of gravity from the broad base?

For a hollow cone, the centre of gravity lies at a distance of 2/3 of its height from the vertex (the pointed end), or 1/3 of the height from the base.

- Height of cone = 6 cm
- Position from broad base =

$$\frac{1}{3} \times 6 = 2 \, \mathrm{cm}$$

Answer: 2 cm from the broad base

2. Will its position change when it is filled completely with honey?

Yes, because now the mass is distributed throughout the volume of the cone, not just on its surface.

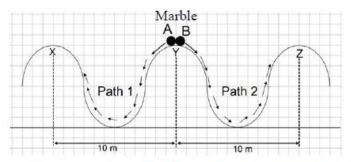
Answer: Yes

Final Answers:

- (a): The point where the entire weight of a body acts.
- (b1): 2 cm from the broad base.
- (b2): Yes.



(ii)



[3]

Two identical marbles A and B are rolled down along Path 1 and Path 2 respectively. Path 1 is **frictionless** and Path 2 is **rough**.

- (a) Which marble will surely reach the next peak?
- (b) Along which path/s the mechanical energy will be conserved?
- (c) Along which path/s is the law of conservation of energy obeyed?

Let's analyze and answer each part based on the diagram and description:

Given:

- Two marbles, A (Path 1) and B (Path 2), start from the same height.
- Path 1 is frictionless → no energy loss.
- Path 2 is rough → energy loss due to friction.

(a) Which marble will surely reach the next peak?

- Marble A moves along the frictionless path, so no energy is lost.
- It will convert all potential energy into kinetic and back to potential energy to reach the same height.

Answer: Marble A



(b) Along which path/s will the mechanical energy be conserved?

- Mechanical energy = Potential energy + Kinetic energy
- Only along Path 1 (frictionless) is mechanical energy conserved.
- In Path 2, friction causes energy to be converted into heat → mechanical energy is not conserved.
- Answer: Path 1

(c) Along which path/s is the law of conservation of energy obeyed?

- The law of conservation of energy is a universal law: energy cannot be created or destroyed, only transformed.
- Even in **Path 2**, though mechanical energy decreases, **total energy** (mechanical + heat) remains constant.
- Answer: Path 1 and Path 2

Final Answers:

- (a): Marble A
- **(b)**: Path 1
- (c): Path 1 and Path 2
- (iii) Given are two pulleys.
 - (a) Copy and complete the labelled diagram connecting the two pulleys with a tackle to obtain Velocity Ratio = 2.
- \bigcirc

[4]

- (b) If Load = 48 kgf and efficiency is 80% then calculate:
 - 1. Mechanical Advantage.
 - Effort needed to lift the load.





Let's solve this step-by-step.

(iii) (a) Diagram with Velocity Ratio = 2

To get Velocity Ratio (VR) = 2, we need a simple pulley system with 1 fixed pulley and 1 movable pulley.

Here's how you complete the diagram:

- The upper pulley should be a fixed pulley (attached to a support).
- The lower pulley should be a movable pulley (attached to the load).
- The **rope** passes over the fixed pulley, then under the movable pulley, and one end of the rope is pulled down as effort.
- ✓ This is a block and tackle system with 2 pulleys (1 fixed + 1 movable), giving VR = 2.

(iii) (b) Given:

- Load $L=48\,\mathrm{kgf}$
- Efficiency $\eta=80\%=0.8$
- Velocity Ratio VR=2



2021

- 8. The relation between CGS and S. I. unit of moment
 - (a) $1 \text{ Nm} = 10^5 \text{ dyne cm}$

 - (b) 1 Nm = 10⁵ dyne (c) 1 Nm = 10⁷ dyne cm
 - (d) $1 \, \text{dyne cm} = 10^7 \, \text{Nm}$

Let's solve this carefully:

SI Unit of Moment of Force:

• 1 Nm (Newton metre)

CGS Unit of Moment of Force:

dyne-cm

Conversion Factors:

- $1 \, \mathrm{N} = 10^5 \, \mathrm{dyne}$
- $1 \, \text{m} = 100 \, \text{cm}$

Relation:

$$1\,\mathrm{Nm} = 1\,\mathrm{N} \times 1\,\mathrm{m} = 10^5\,\mathrm{dyne} \times 100\,\mathrm{cm} = 10^7\,\mathrm{dyne} \cdot \mathrm{cdotpcm}$$

Correct Answer:

 \checkmark (c) 1 Nm = 10^7 dyne·cm



- The energy change during photosynthesis in plants is
 - (a) heat to chemical.
 - (b) light to chemical.
 - (c) chemical to light.
- (d) chemical to heat.

Question:

The energy change during photosynthesis in plants is:

- ✓ Correct Answer:
- (b) light to chemical

Explanation:

- In photosynthesis, plants absorb light energy from the sun using chlorophyll.
- This light energy is converted into chemical energy stored in glucose (a carbohydrate).

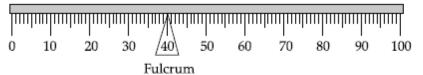
 $Light\ energy \to Chemical\ energy\ (glucose)$

So, the correct energy transformation is light to chemical.

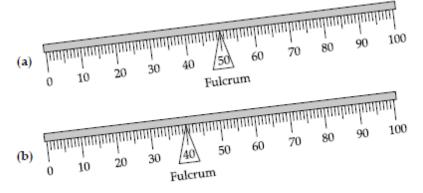


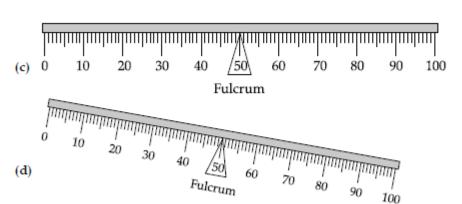
[1]

11. The diagram below shows the balanced position of a metre scale.



Which one of the following diagrams shows the correct position of the scale when it is supported at the centre?







Given:

- The metre scale balances at 40 cm, not at 50 cm.
- This means the mass is unevenly distributed, with more weight toward the 0-40 cm side.

Now, the question asks:

What happens when the same scale is supported at its centre (50 cm mark)?

Reasoning:

- Since the scale's centre of gravity is at 40 cm, when supported at 50 cm:
 - The heavier left side (0-40 cm) will tilt down.
 - The lighter right side (50-100 cm) will tilt up.

Let's examine the options:

- Option (a): Left side is down, right side is up
- Option (b): Left side is up, right side is down X

✓ Correct Answer: (a)

The scale tilts left when supported at its centre because the centre of gravity lies to the left.



- A stone tied at the end of a string is whirled by hand in a horizontal circle with uniform speed.
 - (i) Name the force required for this circular motion [1]
 - (a) Centrifugal force.
 - (b) Centripetal force.
 - (c) Force of gravity.
 - (d) Frictional force.
 - (ii) What is the direction of the above-mentioned force? [1]
 - (a) Towards the centre of the circular path.
 - (b) Away from the centre of the circular path.
 - (c) Normal to the radius at a point where the body is present on the circular path.
 - (d) Direction of this force keeps on changing alternately towards and away from the centre.

12 (i) Name the force required for this circular motion

When a stone is whirled in a circular path, a force is needed to **continuously change its direction** to keep it in circular motion. This force is:

(b) Centripetal force

12 (ii) What is the direction of the above-mentioned force?

- Centripetal force always acts towards the centre of the circular path to keep the object moving in a
 circle.
- Correct Answer: (a) Towards the centre of the circular path

Final Answers:

- (i): (b) Centripetal force
- (ii): (a) Towards the centre of the circular path



- 13. A body of mass 200 g falls freely from a height of 15 m. $[g = 10 \text{ ms}^{-2}]$
 - (i) When the body reaches 10 m above the ground, its potential energy will be [1]
 - (a) 20000 J
- (b) 10 J
- (c) 10000 J
- (d) 20 J
- (ii) The gain in kinetic energy of the body when it reaches 10 m above the ground is [1]
 - (a) 20 J
- (b) 10 J
- (c) 30 J
- (d) 25 J
- (iii) The total mechanical energy it will possess, when it is just about to strike the ground is

[1]

- (a) 30000 J
- (b) 20000 J
- (c) 30 J
- (d) 20 J
- (iv) The velocity in ms⁻¹ with which the body will hit the ground is [1]
 - (a) 30
- (b) 10
- (c) 10√3
- (d) 10√2



Given:

- Mass of body = 200 g = 0.2 kg
- Initial height = 15 m
- $g = 10 \,\mathrm{m/s^2}$
- (i) Potential energy at 10 m above ground

$$PE = mgh = 0.2 \times 10 \times 10 = 20 J$$

- Correct answer: (d) 20 J
- (ii) Gain in kinetic energy when it reaches 10 m above ground
 - Initial PE at 15 m = $0.2 \times 10 \times 15 = 30\,\mathrm{J}$
 - PE at 10 m = 20 J
 - So, loss in PE = gain in KE = $30-20=\boxed{10\,\mathrm{J}}$
- Correct answer: (b) 10 J



(iii) Total mechanical energy just before striking the ground

At any point:

Total Mechanical Energy = PE + KE

- Just before hitting ground: PE = 0, KE = maximum
- That KE = initial total PE = 30 J
- Correct answer: (c) 30 J

Final Answers:

- (i): (d) 20 J
- (ii): (b) 10 J
- (iii): (c) 30 J

Given:

- Body falls freely from a height $h=15\,\mathrm{m}$
- $q = 10 \,\mathrm{m/s}^2$
- ullet Initial velocity u=0

We use the equation:

$$v^2 = u^2 + 2gh \Rightarrow v^2 = 0 + 2 \times 10 \times 15 = 300 \Rightarrow v = \sqrt{300} = \sqrt{100 \times 3} = 10\sqrt{3}$$

- $lap{N}$ Answer: (c) $10\sqrt{3}\,\mathrm{m/s}$
- Final Answer: (c) 10√3



- 14. A woman draws water from a well using a fixed pulley. The mass of the bucket and the water together is 10 kg. The force applied by the woman is 200 N. The mechanical advantage is (g = 10 m/s²)
 [1]
 - (a) 2

(b) 20

- (c) 0.05
- (d) 0.5

Given:

- Mass of bucket + water = 10 kg
- ullet Gravitational acceleration, $g=10\,\mathrm{m/s}^2$
- Force applied = 200 N

Step 1: Calculate Load (Weight)

Load (L) =
$$m \times g = 10 \times 10 = 100 \,\text{N}$$

Step 2: Mechanical Advantage (MA) Formula

$$\mathrm{MA} = \frac{\mathrm{Load}}{\mathrm{Effort}} = \frac{100}{200} = 0.5$$

Final Answer: (d) 0.5





- 15. A single fixed pulley is used because
- [1]
- (a) it changes the direction of applied effort conveniently.
- (b) it multiplies speed.
- (c) it multiplies effort.
- (d) its efficiency is 100%.

Question 15: Why is a single fixed pulley used?

A **single fixed pulley** does **not** multiply force or speed — it only changes the **direction** of the applied force, making it easier to lift loads by pulling **downward** rather than upward.

Correct Answer:

(a) it changes the direction of applied effort conveniently.

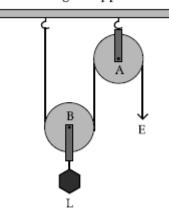
Explanation:

- It does **not** multiply speed or effort.
- Though it may have high efficiency, its main advantage is directional convenience.



16. In the diagram shown below, the velocity ratio of the arrangement is [1]

Rigid Support



(a) 1

(b) 2

(c) 3

(d) 0



Question 16: Velocity Ratio of the Pulley System

The diagram shows a block and tackle system with:

- Pulley A (fixed)
- Pulley **B** (movable, attached to the load L)
- Effort E is applied downward.

Velocity Ratio (VR) for a pulley system:

\text{VR} = \text{Number of rope segments supporting the movable pulley}

In this setup:

- Pulley B is the movable pulley.
- There are 2 rope segments supporting it (one on either side).

Answer: (b) 2

Because 2 segments of the rope support the movable pulley, the Velocity Ratio = 2.



17. Which one of the following is the correct mathematical relation?

- (a) Power= Force / Velocity
- (b) Power= Force × Acceleration
- (c) Power=Force/Acceleration
- (d) Power= Force × Velocity

Question 17: Correct Mathematical Relation for Power

Formula for Power in physics (when a force moves an object at constant velocity):

$$Power = Force \times Velocity$$

This is valid when the force and velocity are in the same direction.

Correct Answer: (d) Power = Force × Velocity

22. 1 joule = [1] (a) 10⁹

(c) 10⁵

(d) 10⁶

Question 22: Conversion of Joules to Ergs

Standard conversion:

$$1 \text{ joule} = 10^7 \text{ erg}$$

 $lap{}$ Correct Answer: (b) 10^7



- A light body A and a heavy body B have the same momentum.
 - Choose a correct statement from the given options.
 - (a) kinetic energy of body A and body B will be the same.
 - (b) kinetic energy of body A is greater than kinetic energy of body B.
 - (c) kinetic energy of body B is greater than kinetic energy of body A.
 - (d) unless we know the velocity, we cannot find which body has greater kinetic energy.
 - (ii) If the ratio of kinetic energies of A and B is 5:2 then which one of the following gives the mass ratio of the bodies respectively? [1]
 - (a) 5:2
- (b) 25:4
- (c) 2:5
- (d) 4:24

(i) Same momentum, but different masses:

Let's recall the formulas:

- Momentum: p = mv
- Kinetic Energy: $KE=rac{1}{2}mv^2$

Now if momentum p is the same for both A and B, but:

- Body A is lighter, and
- Body B is heavier,

Then for the same momentum, the lighter body (A) must be moving faster.

Let's express KE in terms of momentum:

$$KE = rac{p^2}{2m}$$

From this:

- If p is constant,
- Then KE is inversely proportional to mass.

So:

• The lighter body (A) has greater kinetic energy.



Correct Answer for (i): (b)

Kinetic energy of body A is greater than kinetic energy of body B.

(ii) KE ratio of A to B is 5:2 → Find mass ratio?

From above:

$$KE = rac{p^2}{2m} \Rightarrow KE \propto rac{1}{m}$$

So:

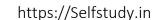
$$rac{KE_A}{KE_B} = rac{m_B}{m_A} \Rightarrow rac{5}{2} = rac{m_B}{m_A} \Rightarrow rac{m_A}{m_B} = rac{2}{5}$$

Correct Answer for (ii): (a) 5:2

This is the mass ratio of B to A, but since the question asks mass ratio of the bodies respectively, answer is:

Mass of A: Mass of B = 2:5

Correct Option: (c) 2:5

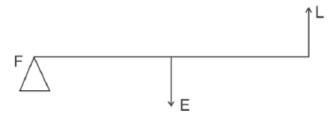




2020

Question 1

- (a) (i) Define moment of force. [2]
 - (ii) Write the relationship between the SI and CGS unit of moment of force.
- (b) Define a kilowatt hour. How is it related to joule? [2]
- (c) A satellite revolves around a planet in a circular orbit. What is the work done [2] by the satellite at any instant? Give a reason.
- (d) (i) Identify the class of the lever shown in the diagram below: [2]



- (ii) How is it possible to increase the M.A. of the above lever without increasing its length?
- (e) Give one example of each when: [2]
 - (i) Chemical energy changes into electrical energy.
 - (ii) Electrical energy changes into sound energy.



(a)

(i) Define moment of force.

The moment of force is the turning effect of a force about a point or axis. It is given by:

\text{Moment of force} = \text{Force} \times \text{Perpendicular distance from the pivot}

(ii) Relationship between SI and CGS unit of moment of force:

- SI unit: Newton metre (Nm)
- CGS unit: dyne centimetre (dyne-cm)

(b)

Define a kilowatt hour. How is it related to joule?

A kilowatt hour (kWh) is the amount of energy consumed when 1 kilowatt (1000 watts) of power is used for 1 hour.

$$1 \, kWh = 1000 \, W \times 3600 \, s = 3.6 \times 10^6 \, J$$

(c)

What is the work done by a satellite at any instant?

The work done is zero.

Reason: The force (gravity) acts **perpendicularly** to the displacement of the satellite (which moves tangentially to its circular path). So,

$$\mathrm{Work} = F \cdot d \cdot \cos(90^\circ) = 0$$



•	_	ı١
u	u	.,

(i) Identify the class of lever shown:

The fulcrum (F) is between the load (L) and the effort (E).

- ✓ This is a first-class lever.
- (ii) How to increase M.A. without increasing length?

Move the **effort closer to the fulcrum** and/or the **load farther from the fulcrum** (increase load arm, decrease effort arm).

(e)

- (i) Example where chemical energy changes into electrical energy:
 - Battery or electric cell
- (ii) Example where electrical energy changes into sound energy:
- Loudspeaker or buzzer



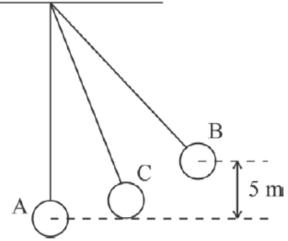
Question 2

(a) A crane 'A' lifts a heavy load in 5 seconds, whereas another crane 'B' does the same work in 2 seconds. Compare the power of crane 'A' to that of crane 'B'.



Question 5

(a) The figure below shows a simple pendulum of mass 200 g. It is displaced from [3] the mean position A to the extreme position B. The potential energy at the position A is zero. At the position B the pendulum bob is raised by 5 m.



- (i) What is the potential energy of the pendulum at the position B?
- (ii) What is the total mechanical energy at point C?
- (iii) What is the speed of the bob at the position A when released from B? (Take $g = 10 \text{ ms}^{-2}$ and there is no loss of energy.)



Given:

- Mass $m = 200 \, \mathrm{g} = 0.2 \, \mathrm{kg}$
- ullet Height raised at position B: $h=5\,\mathrm{m}$
- Potential energy at position A = 0
- $g = 10 \,\mathrm{m/s}^2$

(i) Potential energy at position B:

$$PE = mgh = 0.2 \times 10 \times 5 = 10 \,\mathrm{J}$$

(ii) Total mechanical energy at point C:

- Mechanical energy (ME) is conserved.
- At B, all energy is potential = 10 J.
- At C, mechanical energy is the sum of potential energy + kinetic energy.
- Since no energy loss:

$$ME = 10 \,\mathrm{J}$$



(iii) Speed of the bob at position A (when released from B):

- At A, potential energy is zero, so all mechanical energy converts to kinetic energy.
- Using kinetic energy formula:

$$KE=rac{1}{2}mv^2=ME=10\,\mathrm{J}$$
 $rac{1}{2} imes0.2 imes v^2=10$ $0.1 imes v^2=10\implies v=10\,\mathrm{m/s}$

- (b) (i) With reference to the direction of action, how does a centripetal force differ [3] from a centrifugal force during uniform circular motion?
 - (ii) Is centrifugal force the force of reaction of centripetal force?
 - (iii) Compare the magnitudes of centripetal and centrifugal force.
- (c) A block and tackle system of pulleys has velocity ratio 4. [4]
 - Draw a neat labelled diagram of the system indicating clearly the points of application and direction of load and effort.
 - (ii) What will be its V.R. if the weight of the movable block is doubled?



(b) (i) Difference between centripetal and centrifugal force in direction during uniform circular motion:

- Centripetal force acts towards the center of the circular path (inward).
- Centrifugal force acts away from the center of the circular path (outward).

(b) (ii) Is centrifugal force the reaction force of centripetal force?

- Yes, centrifugal force is the reaction force to the centripetal force, as per Newton's third law.
- Centripetal force acts on the object towards the center, and centrifugal force acts on the rotating frame (or object) outward.

(b) (iii) Compare the magnitudes of centripetal and centrifugal force:

The magnitudes of the centripetal and centrifugal forces are equal.

(c) Block and tackle system with velocity ratio (V.R.) = 4

(i) Diagram:

- The system has 4 pulleys (or the rope passes 4 times supporting the movable pulley).
- ullet Effort E is applied at one end.
- Load L is attached to the movable block.
- Directions: Effort is usually downward or upward depending on the setup, load acts downward.

Here is a simple labelled diagram:

Rope \rightarrow Fixed pulleys on top, movable pulleys below, with rope segments supporting the load L.

Effort (E) \leftarrow applied at the free end of the rope.

Load (L) \rightarrow attached to the movable pulley block.



- (ii) What happens to the velocity ratio (V.R.) if the weight of the movable block is doubled?
 - The velocity ratio depends on the number of supporting rope segments.
 - Weight of the movable block does NOT affect the velocity ratio.

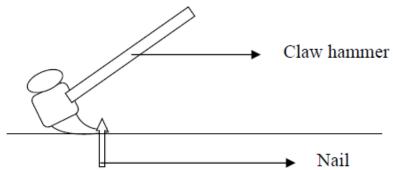
Answer:

• Velocity Ratio will remain the same (4) even if the weight of the movable block is doubled.

2019

Question 1

(a) The diagram below shows a claw hammer used to remove a nail: [2]



- (i) To which class of lever does it belong?
- (ii) Give one more example of the same class of lever mentioned by you in (i) for which the mechanical advantage is greater than one.



- (i) To which class of lever does the claw hammer belong?
- The claw hammer used to remove a nail is a Class 1 lever (first-class lever).
- In this lever, the fulcrum is between the effort and the load (nail).
- (ii) One more example of the same class of lever with mechanical advantage > 1:
- Example: A see-saw (teeter-totter) or a crowbar
- Both are first-class levers where the mechanical advantage can be greater than one depending on the relative positions of the effort and load arms.
- (b) Two bodies A and B have masses in the ratio 5:1 and their kinetic energies are [2] in the ratio 125:9. Find the ratio of their velocities.

Given:

- Mass ratio: $\frac{m_A}{m_B}=\frac{5}{1}$ Kinetic energy ratio: $\frac{KE_A}{KE_B}=\frac{125}{9}$

Find:

Ratio of their velocities $\frac{v_A}{v_B}$.

Step 1: Recall kinetic energy formula

$$KE=\frac{1}{2}mv^2$$

For bodies A and B:

$$rac{KE_{A}}{KE_{B}} = rac{rac{1}{2}m_{A}v_{A}^{2}}{rac{1}{2}m_{B}v_{B}^{2}} = rac{m_{A}v_{A}^{2}}{m_{B}v_{B}^{2}}$$



Step 2: Substitute known ratios:

$$\begin{split} \frac{125}{9} &= \frac{5}{1} \times \frac{v_A^2}{v_B^2} \\ &\frac{125}{9} = 5 \times \frac{v_A^2}{v_B^2} \\ &\frac{v_A^2}{v_B^2} = \frac{125}{9 \times 5} = \frac{125}{45} = \frac{25}{9} \end{split}$$

Step 3: Find velocity ratio

$$rac{v_A}{v_B}=\sqrt{rac{25}{9}}=rac{5}{3}$$

Answer:

$$rac{v_A}{v_B} = rac{5}{3}$$



(c) (i) Name the physical quantity which is measured in calories.

[2]

- (ii) How is calorie related to the S.I unit of that quantity?
- (i) Name the physical quantity which is measured in calories:
- Answer: Energy (specifically, heat energy).
- (ii) How is calorie related to the S.I unit of that quantity?
- 1 calorie is the amount of heat energy required to raise the temperature of 1 gram of water by 1°C.
- In terms of joules (the S.I unit of energy):

1 calorie = 4.18 joules

(d) (i) Define couple.

[2]

- (ii) State the S.I. unit of moment of couple.
- (i) Define couple:
- A couple is a pair of equal and opposite forces, whose lines of action are different (not collinear), producing rotation without translation.
- It tends to produce rotational motion or torque on a body.
- (ii) State the S.I. unit of moment of couple:
 - The S.I. unit of moment of couple is Newton-meter (N·m).



Question 5

- (a) A body of mass 10 Kg is kept at a height of 5 m. It is allowed to fall and reach [3] the ground.
 - (i) What is the total mechanical energy possessed by the body at the height of 2 m assuming it is a frictionless medium?
 - (ii) What is the kinetic energy possessed by the body just before hitting the ground? Take $g = 10 \text{ m} / \text{s}^2$.

Given:

- Mass, $m=10\,\mathrm{kg}$
- Initial height, $h_i = 5 \, \mathrm{m}$
- Height at point considered, $h=2\,\mathrm{m}$
- Gravitational acceleration, $g=10\,\mathrm{m/s}^2$
- Frictionless medium (no loss of energy)

(i) Total mechanical energy at height 2 m:

- Total mechanical energy E = Potential energy (PE) + Kinetic energy (KE)
- In frictionless medium, mechanical energy is conserved. So total energy at any height = initial potential energy.

Initial potential energy at 5 m:

$$PE_i = mgh_i = 10 \times 10 \times 5 = 500\,\mathrm{J}$$

So, total mechanical energy at height 2 m is also:

$$E = 500 \,\mathrm{J}$$



- (ii) Kinetic energy just before hitting the ground (height h=0):
 - Total mechanical energy at ground = kinetic energy (since potential energy = 0 at ground)

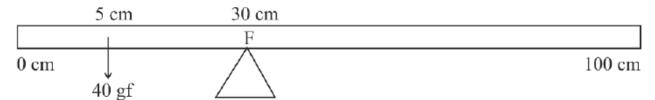
$$KE = E = 500 \,\mathrm{J}$$

Summary:

- (i) Total mechanical energy at 2 m = 500 J
- (ii) Kinetic energy just before hitting ground = 500 J

(b) A uniform meter scale is in equilibrium as shown in the diagram:

[3]



- (i) Calculate the weight of the meter scale.
- (ii) Which of the following options is correct to keep the ruler in equilibrium when 40 gf wt is shifted to 0 cm mark?

F is shifted towards 0 cm.

or

F is shifted towards 100 cm.



Given:

- Length of meter scale = 100 cm
- Fulcrum F is at 30 cm
- Weight W_m of meter scale acts at its center of gravity (50 cm)
- A 40 gf weight is at 5 cm

(i) Calculate the weight of the meter scale:

Using the principle of moments for equilibrium (clockwise moments = anticlockwise moments),

Moment due to 40 gf weight = Moment due to meter scale weight

Distance of 40 gf from fulcrum = $30-5=25\,\mathrm{cm}$

Distance of meter scale's weight from fulcrum = $50-30=20\,\mathrm{cm}$

$$40 \times 25 = W_m \times 20$$

$$W_m = rac{40 imes 25}{20} = rac{1000}{20} = 50\,\mathrm{gf}$$

(ii) Which option is correct to keep the ruler in equilibrium when 40 gf is shifted to 0 cm?

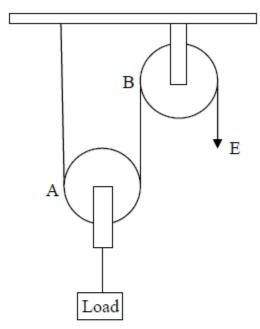
- When the 40 gf weight moves from 5 cm to 0 cm, its moment arm from fulcrum increases from 25 cm to 30 cm.
- To balance this, the fulcrum must be moved towards 100 cm to reduce the moment arm of the 40 gf weight relative to the fulcrum.

Answer: Fulcrum F is shifted towards 100 cm.



(c) The diagram below shows a pulley arrangement:





- Copy the diagram and mark the direction of tension on each strand of the string.
- (ii) What is the velocity ratio of the arrangement?
- (iii) If the tension acting on the string is T, then what is the relationship between T and effort E?
- (iv) If the free end of the string moves through a distance x, find the distance by which the load is raised.



(i) Direction of tension on each strand of the string:

- Tension acts along the string, away from the pulley on both sides.
- At pulley A: tension acts upward on the left side and upward on the right side of the string (since the string passes over the pulley).
- ullet At pulley B: tension acts **upward** on the left side and the effort E pulls downward.

I can help you draw or describe the directions clearly if you want.

(ii) What is the velocity ratio (V.R) of the arrangement?

- Velocity ratio = Number of strands supporting the load.
- Here, pulley A has 2 strands supporting the load.
- Pulley B has 1 strand, but it supports the pulley A.
- So total strands supporting the load = 3.

Velocity ratio V.R=3.

(iii) Relationship between tension T and effort E:

- The effort E pulls the string, so tension in the string T=E.
- Since the string is continuous and ideal (no friction), tension is the same throughout the string.

$$T = E$$

(iv) If the free end of the string moves through a distance x, find the distance by which the load is raised:

- Load moves up by a distance equal to $\frac{x}{V.R}$.
- Since V.R=3,

Distance load is raised =
$$\frac{x}{3}$$



(b) A pendulum has a frequency of 4 vibrations per second. An observer starts the pendulum and fires a gun simultaneously. He hears the echo from the cliff after 6 vibrations of the pendulum. If the velocity of sound in air is 340 m/s, find the distance between the cliff and the observer.

Given:

- Frequency of pendulum, f=4 vibrations per second
- Observer hears echo after 6 vibrations of the pendulum
- Velocity of sound, $v=340\,m/s$

Step 1: Calculate the time taken for 6 vibrations

Since frequency $f=rac{1}{T}$ (where T is the time period),

$$T = \frac{1}{f} = \frac{1}{4} = 0.25$$
 seconds per vibration

Time for 6 vibrations:

$$t=6\times T=6\times 0.25=1.5\,\mathrm{seconds}$$

Step 2: Calculate the distance between the cliff and the observer

The echo travels from observer to cliff and back, so total distance covered by sound:

$$d_{total} = v \times t = 340 \times 1.5 = 510 \, \mathrm{meters}$$



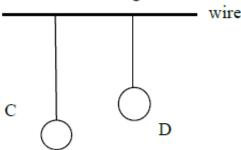
Distance between cliff and observer (one-way distance):

$$d=rac{d_{total}}{2}=rac{510}{2}=255\,\mathrm{meters}$$

Answer:

The distance between the cliff and the observer is 255 meters.

(c) Two pendulums C and D are suspended from a wire as shown in the figure given below. Pendulum C is made to oscillate by displacing it from its mean position. It is seen that D also starts oscillating.



- (i) Name the type of oscillation, C will execute.
- (ii) Name the type of oscillation, D will execute.
- (iii) If the length of D is made equal to C then what difference will you notice in the oscillations of D?
- (iv) What is the name of the phenomenon when the length of D is made equal to C?



(i)

Type of oscillation that pendulum C will execute:

Free oscillation (or simple harmonic motion)

(ii)

Type of oscillation that pendulum D will execute:

Forced oscillation (because pendulum D starts oscillating due to pendulum C's motion)

(iii)

If the length of D is made equal to C, the difference you will notice in the oscillations of D is:

Pendulum D will oscillate with **maximum amplitude** because its natural frequency will match the frequency of pendulum C.

(iv)

The name of the phenomenon when the length of D is made equal to C:

Resonance



2018

Question 1

(a) (i) State and define the S.I. unit of power.

[2]

(ii) How is the unit horse power related to the S.I. unit of power?

(a)(i)

State and define the S.I. unit of power:

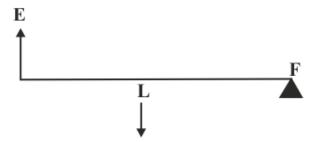
- The S.I. unit of power is the watt (W).
- ullet Definition: One watt is the power when one joule of work is done in one second. Mathematically, $1\,\mathrm{W}=1\,\mathrm{J/s}$.

(a)(ii)

How is the unit horsepower related to the S.I. unit of power?

- 1 horsepower (hp) = 746 watts (W).
- (c) The diagram below shows a lever in use:

[2]



- (i) To which class of levers does it belong?
- (ii) Without changing the dimensions of the lever, if the load is shifted towards the fulcrum what happens to the mechanical advantage of the lever?



(c)(i)

The lever shown belongs to the **first class of levers** because the fulcrum (F) is between the effort (E) and the load (L).

(c)(ii)

If the load is shifted towards the fulcrum without changing the dimensions of the lever, the **mechanical advantage of the lever increases**.

- This is because the effort arm (distance from fulcrum to effort) remains the same, but the load arm (distance from fulcrum to load) decreases, so the ratio (effort arm ÷ load arm) increases.
- (e) (i) Why is the motion of a body moving with a constant speed around a [2] circular path said to be accelerated?
 - (ii) Name the unit of physical quantity obtained by the formula $\frac{2 K}{V^2}$.

Where K: kinetic energy, V: Linear velocity.

(e)(i)

The motion of a body moving with a constant speed around a circular path is said to be accelerated because **its direction is continuously changing**, and acceleration depends on the change in velocity (which includes direction). This type of acceleration is called **centripetal acceleration**.

(e)(ii)

The physical quantity obtained by the formula $\frac{2K}{V^2}$, where K is kinetic energy and V is linear velocity, is mass. This is because kinetic energy $K=\frac{1}{2}mV^2$, so rearranging gives $m=\frac{2K}{V^2}$.



Question 5

- (a) (i) Derive a relationship between S.I. and C.G.S. unit of work.
- [3]
- (ii) A force acts on a body and displaces it by a distance S in a direction at an angle θ with the direction of force. What should be the value of θ to get the maximum positive work?

(a)(i) Derive a relationship between S.I. and C.G.S. unit of work.

- Work done (W) = Force (F) \times displacement (s) \times cos θ
- The S.I. unit of work is joule (J).
- 1 joule = 1 newton × 1 meter = 1 Nm.

Convert Newton to dyne and meter to centimeter:

- 1 newton = 10^5 dyne
- 1 meter = 100 centimeters = 10^2 cm

So,

1 joule =
$$1 \text{ Nm} = (10^5 \text{ dyne}) \times (10^2 \text{ cm}) = 10^7 \text{ dyne cm}$$

Thus,

1 joule = 10^7 dyne cm

(a)(ii) A force acts on a body and displaces it by a distance S in a direction at an angle θ with the direction of force. What should be the value of θ to get the maximum positive work?

- Work done $W = F \times S \times \cos \theta$
- To get the maximum positive work, $\cos heta$ must be maximum, which is 1.

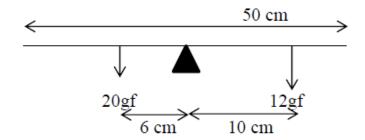
Therefore,

$$\theta = 0^{\circ}$$

The force and displacement should be in the **same direction** to get the maximum positive work.



(b) A half metre rod is pivoted at the centre with two weights of 20 gf and 12 gf [3] suspended at a perpendicular distance of 6 cm and 10 cm from the pivot respectively as shown below.



- (i) Which of the two forces acting on the rigid rod causes clockwise moment?
- (ii) Is the rod in equilibrium?
- (iii) The direction of 20 gf force is reversed. What is the magnitude of the resultant moment of the forces on the rod?

(b)(i) Which of the two forces acting on the rigid rod causes clockwise moment?

- The 12 gf force acts downward on the right side of the pivot, causing a **clockwise moment**.
- The 20 gf force acts downward on the left side of the pivot, causing an anticlockwise moment.

Answer: The **12 gf force** causes the clockwise moment.

(b)(ii) Is the rod in equilibrium?

To check equilibrium, sum of clockwise moments = sum of anticlockwise moments.

- Clockwise moment = $12 \times 10 = 120 \, \mathrm{gf} \, \mathrm{cm}$
- Anticlockwise moment = $20 \times 6 = 120 \,\mathrm{gf}\,\mathrm{cm}$

Since they are equal, the rod is balanced and in equilibrium.

Answer: Yes, the rod is in equilibrium.



(b)(iii) The direction of 20 gf force is reversed. What is the magnitude of the resultant moment of the forces on the rod?

- Original 20 gf force acts downward, now it acts **upward** at 6 cm from the pivot.
- The 12 gf force remains acting downward at 10 cm from the pivot.

Calculate moments (taking clockwise as positive):

- Moment of 20 gf force = $20 \times 6 = 120 \, \mathrm{gf \ cm}$ but now **upward**, so it causes **clockwise** moment.
- Moment of 12 gf force = $12 \times 10 = 120 \, \mathrm{gf \, cm}$ downward, causing clockwise moment.

Since both moments are in the same direction (clockwise), resultant moment is the sum:

Resultant moment =
$$120 + 120 = 240 \,\mathrm{gf}$$
 cm

Answer: The magnitude of the resultant moment is 240 gf cm.

- (c) (i) Draw a diagram to show a block and tackle pulley system having a velocity [4] ratio of 3 marking the direction of load(L), effort(E) and tension(T).
 - (ii) The pulley system drawn lifts a load of 150 N when an effort of 60 N is applied. Find its mechanical advantage.
 - (iii) Is the above pulley system an ideal machine or not?



(c)(i) Draw a block and tackle pulley system with velocity ratio (V.R.) = 3, mark directions of Load (L), Effort (E), and Tension (T).

Here's a description of the diagram you can draw:

- A block and tackle system with 3 pulleys in the movable block.
- The load (L) is attached to the movable block, acting downward.
- The **effort (E)** is applied upward at the free end of the rope.
- The tension (T) acts along the rope strands, directed away from the pulleys (upwards in the effort side, and upwards in each segment supporting the load).

If you want, I can help create a sketch for you.

(c)(ii) Mechanical advantage (M.A.)

Given:

- Load $L=150\,N$
- Effort $E=60\,N$

$$\text{Mechanical Advantage (M.A.)} = \frac{\text{Load}}{\text{Effort}} = \frac{150}{60} = 2.5$$

(c)(iii) Is the pulley system ideal?

- An ideal machine has no frictional losses, so Mechanical Advantage (M.A.) = Velocity Ratio (V.R.).
- Here, V.R. = 3 and M.A. = 2.5,
- Since M.A. < V.R., the pulley system is **not ideal** (there are losses).



Question 10

(a)



The diagram shows a coil wound around a U shape soft iron bar AB.

- (i) What is the polarity induced at the ends A and B when the switch is pressed?
- (ii) Suggest one way to strengthen the magnetic field in the electromagnet.
- (iii) What will be the polarities at A & B if the direction of current is reversed in the circuit?



(i) Polarity induced at ends A and B when the switch is pressed

- When the switch is pressed, current flows through the coil, creating a magnetic field.
- Using the right-hand rule for solenoids:
 - . If current flows in the direction shown, A becomes the North (N) pole,
 - and B becomes the South (S) pole.

(ii) One way to strengthen the magnetic field in the electromagnet

- Increase the current flowing through the coil.
- Increase the number of turns of the coil.
- Use a soft iron core (which is already used here) to concentrate and strengthen the field.
- Use a powerful battery or reduce resistance in the circuit.

(iii) Polarity at A & B if the direction of current is reversed

- If the current direction reverses,
 - The polarity of the electromagnet reverses.
 - So, A will become South (S) pole,
 - and B will become North (N) pole.



2017

Question 1

- (a) A brass ball is hanging from a stiff cotton thread. Draw a neat labelled diagram [2] showing the forces acting on the brass ball and the cotton thread.
- (b) The distance between two bodies is doubled. How is the magnitude of [2] gravitational force between them affected?
- (c) Why is a jack screw provided with a long arm? [2]
- (d) If the power of a motor be 100 kW, at what speed can it raise a load of [2] 50,000 N?
- (e) Which class of lever will always have MA > 1 and why? [2]

(a) Draw a neat labelled diagram showing forces on the brass ball and cotton thread

- Diagram description:
 - A brass ball hanging from a cotton thread.
 - Forces acting on the ball:
 - Weight (W) acting downward (gravity).
 - Tension (T) in the cotton thread acting upward along the thread.

Tension (T) ↑

|
|
(cotton thread)
|
• ← Brass ball
↓

Weight (W)



(b) The distance between two bodies is doubled. How is the magnitude of gravitational force affected?

· Gravitational force formula:

$$F = G \frac{m_1 m_2}{r^2}$$

- When distance r is doubled, new distance r'=2r.
- New force:

$$F'=Grac{m_1m_2}{(2r)^2}=Grac{m_1m_2}{4r^2}=rac{F}{4}$$

· Answer: The gravitational force becomes one-fourth of the original force.

(c) Why is a jack screw provided with a long arm?

- To increase the mechanical advantage.
- A long arm means a larger effort arm in the lever mechanism.
- · This reduces the effort needed to turn the screw and lift heavy loads.

(d) If the power of a motor is 100 kW, at what speed can it raise a load of 50,000 N?

- ullet Power P=F imes v
- Rearranging for velocity v:

$$v = \frac{P}{F}$$

Given:

$$P = 100 \,\mathrm{kW} = 100,000 \,\mathrm{W}, \quad F = 50,000 \,\mathrm{N}$$

· Calculate:

$$v = \frac{100,000}{50,000} = 2 \,\mathrm{m/s}$$

(e) Which class of lever will always have mechanical advantage (MA) > 1 and why?

- Class 2 lever always has $\mathrm{MA} > 1$.
- This is because in a class 2 lever, the **load lies between the effort and the fulcrum**, making the effort arm always longer than the load arm.



Question 5

- (a) A uniform half metre rule balances horizontally on a knife edge at 29 cm mark [3] when a weight of 20 gf is suspended from one end.
 - (i) Draw a diagram of the arrangement.
 - (ii) What is the weight of the half metre rule?

(a)(i) Diagram of the arrangement:

- The weight of 20 gf is suspended at the left end (0 cm).
- · The uniform half-meter rule is balanced on a knife edge at the 29 cm mark.
- The weight of the rule acts at its center, which is at 25 cm.

(a)(ii) Calculate the weight of the half meter rule

Given:

- ullet Weight suspended, $W_1=20\,\mathrm{gf}$
- Distance of W_1 from knife edge = 29 cm
- Weight of rule = W (unknown)
- ullet Distance of weight of rule from knife edge = $|29-25|=4\,\mathrm{cm}$



Using principle of moments:

 $Clockwise\ moment = Anticlockwise\ moment$

$$W_1 \times 29 = W \times 4$$

$$20 \times 29 = W \times 4$$

$$580 = 4W$$

$$W=\frac{580}{4}=145\,\mathrm{gf}$$

Answer: The weight of the half meter rule is 145 gf.



- (b) (i) A boy uses a single fixed pulley to lift a load of 50 Kgf to some height. [3] Another boy uses a single movable pulley to lift the same load to the same height. Compare the effort applied by them. Give a reason to support your answer.
 - (ii) How does uniform circular motion differ from uniform linear motion?
 - (iii) Name the process used for producing electricity using nuclear energy.

Fixed pulley:

- Effort applied = Load = 50 kgf.
- · It only changes the direction of the force.

Movable pulley:

- Effort applied = Load / 2 = 50 kgf / 2 = 25 kgf.
- · It reduces the effort needed by half.

Reason:

A movable pulley provides a mechanical advantage of 2 because the load is shared between two segments of the rope.

(b)(ii) Difference between uniform circular motion and uniform linear motion:

Uniform Circular Motion	Uniform Linear Motion
The object moves in a circular path.	The object moves in a straight line.
The direction of velocity constantly changes.	The direction of velocity remains constant.
The object is accelerated (centripetal acceleration).	The object is not accelerated (constant velocity).



/ \ \ /***	_ (
(h)(iii)	Dracace to	ar produc	ina alacti	ricitv/ licir	an nucl	lear energy:
(1111)	LIOCE33 IC	JI DIOGUC	iiid elect	HCILY USII	iu iiuci	cai cheigy.
. , . ,			_	,	_	"

Nuclear fission is the process used to produce electricity by splitting the nucleus of heavy atoms like uranium or plutonium, releasing a large amount of energy.



(c) A pulley system with VR = 4 is used to lift a load of 175 kgf through a vertical [4] height of 15 m. The effort required is 50 kgf in the downward direction.

$$(g = 10 \text{ N kg}^{-1})$$

Calculate:

- (i) Distance moved by the effort.
- (ii) Work done by the effort.
- (iii) M.A. of the pulley system.
- (iv) Efficiency of the pulley system.

Given:

- Velocity Ratio (VR) = 4
- Load $W=175\,\mathrm{kgf}$
- Height lifted $h=15\,\mathrm{m}$
- Effort $E=50\,\mathrm{kgf}$
- $g=10\,\mathrm{N/kg}$ (Note: since weights are given in kgf, g is not directly needed)
- (i) Distance moved by the effort:

Distance moved by effort = $VR \times$ Distance moved by load

Distance moved by load = height lifted = 15 m

 \Rightarrow Distance moved by effort = $4 \times 15 = 60 \,\mathrm{m}$

(ii) Work done by the effort:

Work done = Effort \times Distance moved by effort

 $= 50 \, \mathrm{kgf} \times 60 \, \mathrm{m}$



(iii) Mechanical Advantage (M.A.):

$$M.A. = \frac{\mathrm{Load}}{\mathrm{Effort}} = \frac{175}{50} = 3.5$$

(iv) Efficiency of the pulley system:

Efficiency =
$$\frac{M.A.}{V.R.} \times 100 = \frac{3.5}{4} \times 100 = 87.5\%$$

- (i) A moment of couple has a tendency to rotate the body in an anticlockwise direction. Then the moment of couple is taken as:
 - positive (a)
 - (b) negative
 - maximum
 - (d) zero

The answer is:

(a) positive

Explanation:

By convention, a moment (or torque) that tends to rotate a body in the anticlockwise direction is considered positive, and a moment that tends to rotate in the clockwise direction is considered negative.



- (ii) The kinetic energy of a given body depends on the:
 - (a) position
 - (b) centre of gravity of the body.
 - (c) momentum
 - (d) displacement

(c) momentum

Explanation:

Kinetic energy of a body depends on its mass and velocity, and since momentum is the product of mass and velocity, kinetic energy depends on the momentum of the body.

(iv) The adjacent diagram shows the movable block of a block and tackle system with effort in a convenient direction. From the diagram we can conclude that the number of pulleys used in the fixed block are _____.



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

[6]



From the given image of the block and tackle system, we can observe:

- The movable block has two pulleys.
- The fixed block (the one attached to the support) has two pulleys as well.

Answer:

The number of pulleys used in the fixed block are 2.

So, the correct option is:

(c) 2

Ques	tion 2	
(i)		inplete the following by choosing the correct answers from the eket:
	(a)	A[class I/class III/Class III] lever will always have M.A. > 1.
	(b)	In a block and tackle system, increase in the weight of the movable block [decreases, does not affect, increases] the efficiency of the pulley system.
	(c)	If the mass as well as the velocity of a body is doubled then the kinetic energy of the body [is doubled/becomes eight times / becomes four times] the initial kinetic energy.
	(d)	Unit of power used in mechanical engineering is[watt / horse power / erg per second]
(e)		copper wires can have the different [resistivity / ance] but will have same [resistance / ivity]



- (a) A Class II lever will always have M.A. > 1.
- (b) In a block and tackle system, increase in the weight of the movable block **decreases** the efficiency of the pulley system.
- (c) If the mass as well as the velocity of a body is doubled then the kinetic energy of the body **becomes eight times** the initial kinetic energy.
- (d) Unit of power used in mechanical engineering is watt.
- (e) Two copper wires can have different resistance but will have the same resistivity.
- (ii) Draw a graph of potential energy vs height for a body thrown vertically upwards. [Assume no friction is present.]

Here's a clear explanation and graph for **potential energy (PE) vs height (h)** for a body thrown vertically upwards, assuming no friction:

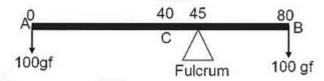
Explanation:

- Potential energy is given by PE = mgh.
- ullet As the body moves up, height h increases.
- Potential energy increases linearly with height.
- At the highest point, potential energy is maximum.
- At the starting point (ground level), potential energy is zero.
- The graph is a straight line starting from the origin (0,0).
- It slopes upward, indicating PE increases with height.
- Linear relationship because PE is directly proportional to height.



Question 6

(i)



A metal rod AB of length 80 cm is balanced at 45 cm from the end A with 100 gf weights suspended from the two ends.

- (a) If this rod is cut at the centre C, then compare the weight of AC to the weight of BC.
- (b) Give a reason for your answer in (a)

Given:

- Metal rod AB length = 80 cm
- Fulcrum at 45 cm from end A
- · 100 gf weight suspended at both ends A and B

Question (a):

If the rod is cut at point C (the fulcrum), compare the weight of AC to BC.

- AC length = 45 cm
- BC length = 80 cm 45 cm = 35 cm
- · Both ends have 100 gf weight suspended.

Since the rod balances at C, the moments about C must be equal:

Weight of AC
$$\times$$
 45 = Weight of BC \times 35



Let weight of AC = W_{AC} and weight of BC = W_{BC} .

$$W_{AC} imes 45 = W_{BC} imes 35$$

$$rac{W_{AC}}{W_{BC}} = rac{35}{45} = rac{7}{9}$$

So, weight of AC is $\frac{7}{9}$ of the weight of BC.

Question (b):

Reason:

The rod is uniform and balances at the fulcrum, so the moments on both sides of the fulcrum are equal. Since the lengths are different, the weights of the segments must be proportional to their lengths for the moments to balance.

Question 7

- A block and tackle system of pulleys has velocity ratio 4.
 - (a) Draw a labelled diagram of the system indicating clearly, the direction of the load and effort.
 - (b) Calculate the potential energy of the load 100 kgf lifted by this pulley to a height 5 m. (g = 10 ms⁻²)
- (i) (a) Draw a labelled diagram of a block and tackle pulley system with velocity ratio 4, showing the directions of load and effort.

Description for diagram:

- The system has 4 supporting ropes (since velocity ratio = 4).
- The load (L) is suspended from the movable pulley.
- The effort (E) is applied on the rope going upwards.
- The tension (T) is the force in the rope segments.



(i) (b) Calculate the potential energy of the load:

- Load = 100 kgf
- Height = 5 m
- $g = 10 \, m/s^2$

Formula for potential energy (PE):

$$PE = mgh$$

Since load is given in kgf, we treat it as force (weight) in Newtons (1 kgf = 9.8 N, but here we can approximate to 10 N for simplicity).

$$PE = \text{weight} \times \text{height} = 100 \, kgf \times 5 \, m = 500 \, J$$

Final answers:

- Diagram: Block and tackle with velocity ratio 4, showing load, effort, and tension directions.
- Potential energy = 500 Joules