THE CAMBRIDGE SCHOOL

A PROJECT OF AZAM ACADEMY

PHYSICS

FOR CLASS – 9th

WEBSITE ***WWW.CAMBRIDGEISB.COM***

WHATSAPP NUMBER *+92312-2888800*

PHONE *051- 2303786*

YOUTUBE CHANNEL *The Cambridge School*

FACEBOOK *TheCambridgeSchool.Official*

Email *tcschool.bk*

پتہ: کرنل امان اللہ روڈ نزد آرمی کیمپ بھارہ کہو اسلام آباد

Chapter#1

PHYSICAL QUANTITIES AND MEASUREMENT

MULTIPLE CHOICE QUESTIONS

1. Choose the best possible option.

(i) Which of the following is a base unit?
(a) pascal (b) coulomb (c) metre per second (d) mole ✓

(ii) Ratio of millimeter to micrometer is
(a) 1000 metre (b) 0.001 metre (c) 1000 ✓ (d) 0.001

(iii) Which of the following prefix represents a largest value?
(a) mega (b) pico (c) peta ✓ (d) kilo

(iv) Which of the following quantity can be measured using a micrometer?
(a) current (b) force (c) length ✓ (d) mass

(v) The instrument best measures the internal diameter of a pipe is
(a) screw gauge (b) vernier caliper ✓ (c) metre rule (d) measuring tape

(vi) Least count of screw gauge is 0.01mm. If main scale reading of screw gauge is zero and third line of its circular scale coincides with datum line then the measurement on the screw gauge is:
(a) 0mm (b) 3mm (c) 0.03mm ✓ (d) 0.3mm

(vii) $9.483 \times 10^3 m$ is the standard form of
(a) 94.83m (b) 9.483m (c) 948.3m (d) 9483m ✓

(viii) How many significant figures are in 0.00350s?
(a) 2 (b) 3 ✓ (c) 5 (d) 6

(ix) Which of the following numbers shows one significant digit?
(a) 1.1 (b) 6.0 (c) 7.1 (d) 6×10^2 ✓

(x) Which of the following numbers shows 4 significant digits?
(a) 900.8 (b) 4 (c) 5174.00 (d) 0.001248 ✓

(xi) 0.2mm in units of metres is
(a) $0.0002m$ ✓ (b) $2 \times 10^{-3} m$ (c) $0.02m$ (d) $0.002m$

CONCEPTUAL QUESTIONS

2. Give short response to the following questions

(i) "Physics has made our lives comfortable." Justify this statement.

Physics has made our lives comfortable in a lot of way. The devices we use on a regular basis like computer, smart phone, internet etc. and the devices like rocket, space shuttle, train and robots are all based on the principles of Physics.

The discoveries or inventions of electricity, wireless communication, X-rays, computers, automobiles etc. have affected our lives in a way that we no longer can imagine our life without the technologies developed using the medium of Physics.

(ii) What base quantities are involved in these derived physical quantities; force, pressure, power and charge.

Quantity	Derived unit	Involved base quantities
Force	$kgms^{-2}$	Mass, Length, Time
Pressure	$kgm^{-1}s^{-2}$	Mass, Length, Time

Power	kgm^2s^{-2}	Mass, Length, Time
Charge	As	Current, time

(iii) Show that prefix micro is thousand times greater than prefix nano.

$= \mu$
$= 10^{-6}$
$= 10^{-6} \times 10^{-3} \times 10^{3}$
$= 10^{-9} \times 1000$
$= 1000n$

(iv) Screw gauge can give more precise length than vernier calipers. Briefly explain why?

The instrument which has smaller least count will give more precise value.
The least count of the screw gauge is less than the least count of vernier callipers, so Screw gauge can give more precise length than vernier calipers.

(v) Differentiate between mechanical stop watch and digital stop watch.

Mechanical Stop Watch	Digital Stop Watch
1. Mechanical stop watch has only one knob at top of it. Which is used to start stop and reset the stopwatch. 2. Mechanical stopwatch can measure a time interval up to a minimum 0.1 second. 3. Mechanical stop watch is less accurate then digital stopwatch.	1. Digital stopwatch has two buttons. One for start/stop and other one for reset the stopwatch. 2. Digital stopwatch can measure time interval up to a minimum 0.01 second. 3. Digital stop watch is more accurate then mechanical stopwatch.

(vi) How measuring cylinder is used to measure volume of an irregular shaped stone?

Take some water in a measuring cylinder. Note the volume V_i of water in the cylinder. Tie an irregular shaped stone with a thread. Lower the stone into the cylinder till it is fully immersed in water. Note the volume V_f of water having stone in it. Volume of the solid will be $V = V_f - V_i$

(vii) What precaution should be kept in mind while taking measurement using measuring cylinder?

Following precaution must be followed.

i. While using a measuring cylinder, it must be kept vertical on a plane surface.
ii. The correct method to note the level of a liquid in the cylinder is to keep the eye at the same level as the meniscus of the liquid.
iii. Formation of bubbles inside the cylinder should be completely avoided. Any bubbles within leads to wrong measurements.

(viii) Why do we need to consider significant digits in measurements?

Significant figures tell us what amount of uncertainty we have in a reported value. The more digits we have, the more sure of our self we are. That is why we should almost never report all the decimal places we see in our calculator.

NUMERICAL PROBLEMS

Q. Solve the questions given below.

1. Write the following numbers in scientific notations

a. $1234m$ **b. $0.000023s$** **c. $469.3 \times 10^5 m$** **d. $0.00985 \times 10^7 s$**

Solution:

a. 1234m	b. 0.000023s	c. $469.3 \times 10^5 m$	d. $0.00985 \times 10^7 s$
$1234m$ $1.234 \times 10^3 m$	$0.000023s$ $2.3 \times 10^{-5} s$	$469.3 \times 10^5 m$ $4.693 \times 10^{5+2} m$	$0.00985 \times 10^7 s$ $9.85 \times 10^{7-3} s$

		$4.693 \times 10^7 m$	$9.85 \times 10^4 s$

2. Express the following measurements using prefixes

a. $27.5 \times 10^{-10} m$ **b. $0.00023 \times 10^{-2} s$**

Solution:

a. $27.5 \times 10^{-10} m$	**b. $0.00023 \times 10^{-2} s$**
$27.5 \times 10^{-10} m$	$0.00023 \times 10^{-2} s$
$2.75 \times 10^{-10+1} m$	$2.3 \times 10^{-2-4} s$
$2.75 \times 10^{-9} m$	$2.3 \times 10^{-6} s$
$2.75nm$	$2.3\mu s$

3. If a boy has age of 15 years 2 months and 10 days, convert his age in

a. seconds **b. milli seconds** **c. mega seconds**

Solution:

15 Years into Seconds	**2 Months into seconds**	**10 days into Seconds**
$15\ years$	$2\ months$	$10\ days$
$= 15 \times 365\ days$	$= 2 \times 30\ days$	$= 10 \times 24\ hours$
$= 15 \times 365 \times 24\ hours$	$= 2 \times 30 \times 24\ hours$	$= 10 \times 24 \times 60\ minuts$
$= 15 \times 365 \times 24 \times 60\ minuts$	$= 2 \times 30 \times 24 \times 60\ minuts$	$= 10 \times 24 \times 60 \times 60s$
$= 15 \times 365 \times 24 \times 60 \times 60s$	$= 2 \times 30 \times 24 \times 60 \times 60s$	$= 864{,}000s$
$= 473{,}040{,}000s$	$= 5{,}184{,}000s$	

a. Seconds

$= 473{,}040{,}000 + 5{,}184{,}000 + 854.000$

$= 479{,}078{,}000s$

$= 4.79078 \times 10^8 s$

b. milli seconds

$= 4.79078 \times 10^8 \times 10^3 \times 10^{-3} s$

$= 4.79078 \times 10^{11} ms$

c. Mega seconds

$= 4.79078 \times 10^8 \times 10^{-6} \times 10^6 s$

$= 4.79078 \times 10^2 Ms$

$= 479.078 Ms$

4. How many kilo meters are there in 25 micrometers?

$25\mu m$

$= 25 \times 10^{-6} m$

$= 25 \times 10^{-6} \times 10^{-3} \times 10^3 m$

$= 25 \times 10^{-9} km$

5. What is pitch and least count of

a. Vernier calipers if the smallest division on main scale is 1mm and total divisions on vernier scale are 20.

Vernier calipers has no pitch.

$$Least\ Count = \frac{smallest\ division\ on\ main\ scale}{Total\ divisions\ on\ vernier\ scale}$$

$$Least\ count = \frac{1mm}{20} = 0.05mm$$

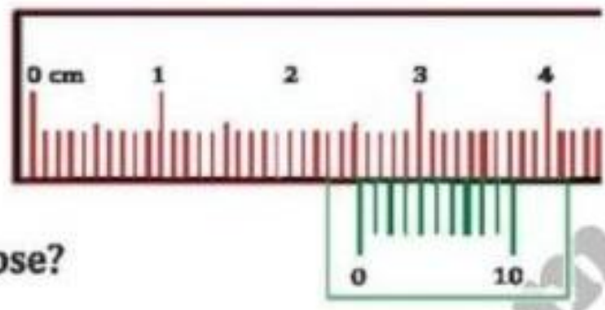
b. Screw gauge if the smallest division on its main scale is 0.5mm and its movable scale has 50 divisions.

Pitch of the screw gauge is the distance moved by the spindle per revolution which is given as 0.5mm

$$Least\ Count = \frac{Pitch}{number\ of\ divisions}$$

$$Least\ count = \frac{0.5mm}{50} = 0.01mm$$

6. **Look at the measurement of vernier caliper (as shown):**



a. What is its main scale reading?

$2.5cm$

b. What is its coinciding division on vernier scale?

8

c. Calculate total reading on the vernier caliper suppose?

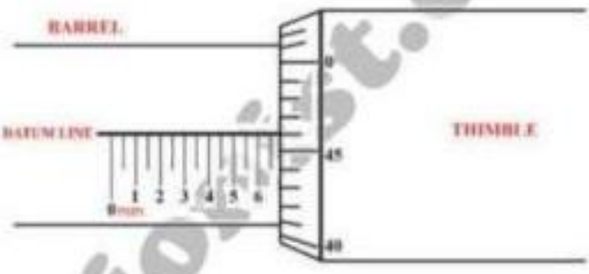
$= M.S\ Reading + V.S\ Reading \times L.C$

$= 2.5cm + 8 \times 0.01cm$

$= 2.5cm + 0.08cm$

$= 2.58cm$

7. **Look at the figure of screw gauge, let's suppose a small steel ball is placed between its spindle and anvil then:**



a. What is its main scale reading?

$= 6.5mm$

b. What is coinciding division of circular scale?

$= 46$

c. Calculate the total diameter of the ball?

$= 6.5mm + 46 \times 0.01mm$

$= 6.5mm + 0.46mm$

$= 6.96mm$

Chapter#2

KINEMATICS

MULTIPLE CHOICE QUESTIONS

1. Encircle the best possible option.

(i) Change in position of a body from initial to final point is called:
(a) Distance (b) Displacement ✓ (c) Speed (d) Velocity

(ii) Motion of a screw of rotating fan is
(a) Circular motion (b) Vibratory motion (c) Random motion (d) Rotatory motion ✓

(iii) For a car in motion for some time
(a) distance and displacement must be equal (b) distance must be greater than displacement ✓
(c) distance must be smaller then displacement (d) distance may be smaller or equal to displacement

(iv) A girl walks 3km towards west and 4km towards south. What is her total distance and displacement respectively?
(a) 7km, 7km (b) 1km, 7km (c) 7km, 1km (d) 7km, 5km ✓

(v) A rider is training a horse. Horse moves 60 meters towards right in 3 second. Then it turns back and travels 30 metres in 2 seconds. Find its average velocity?
(a) 6 m/s (b) 18 m/s ✓ (c) 35 m/s (d) zero

(vi) If a cyclist has acceleration of $2ms^{-2}$ for 5 seconds, the change in velocity of the cyclist is
(a) $2ms^{-1}$ (b) $10\ ms^{-1}$ ✓ (c) $20ms^{-1}$ (d) $15ms^{-1}$

(vii) A car is moving with velocity of $10ms^{-1}$. If it has acceleration of $2ms^{-2}$ for 10 seconds. What is final velocity of the car?

(a) $30ms^{-1}$ ✓ (b) $20ms^{-1}$ (c) $10ms^{-1}$ (d) $15ms^{-1}$

(viii) When the slope of body's displacement-time graph increases, the body is moving with:

(a) increasing velocity (b) decreasing velocity (c) constant velocity ✓ (d) all of these

(ix) A ball is thrown straight up, what is its acceleration at the top of its path?

(a) zero ✓ (b) $10ms^{-1}$ (c) $5ms^{-1}$ (d) $20ms^{-1}$

(x) Slope of distance-time graph is:

(a) velocity (b) acceleration (c) speed ✓ (d) displacement

(xi) Area under speed time graph is equal to _____ of moving body.

(a) distance ✓ (b) change in velocity (c) uniform velocity (d) acceleration

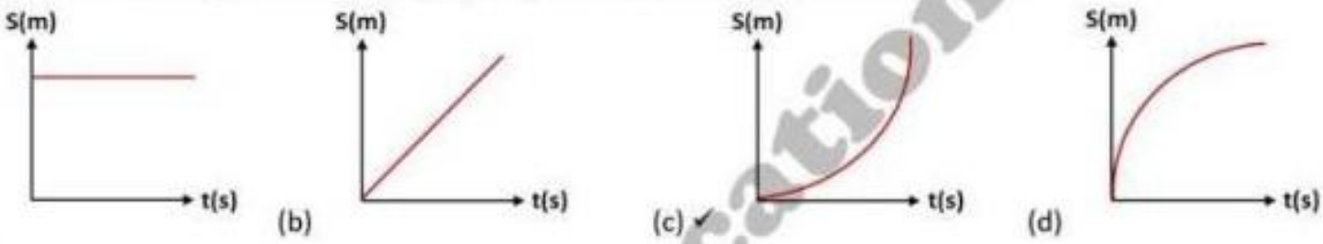
(xii) Which of the following is a vector quantity?

(a) speed (b) pressure (c) gravitational acceleration ✓ (d) distance

(xiii) Ball thrown freely from a tower reaches ground in 4s, the height of tower is about

(a) 20m (b) 40m (c) 80m ✓ (d) 160m

(xiv) Which of following distance time graph represents increasing speed of a car?



(a) (b) (c) ✓ (d)

EXERCISE QUESTIONS

2. Give a short response to the following questions

(i) In a park, children are enjoying a ride on big wheel as shown. What kind of motion the big wheel has and what kind of motion the riders have?

Children are enjoying a ride on a bid wheel.

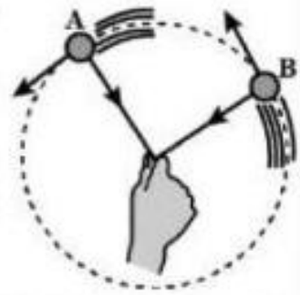
The motion of the children is in circle so the motion of the children is called circular motion.

Big wheel is rotating about its axis so the motion of the wheel is called rotatory motion.

(ii) A boy moves for some time, give two situations in which his displacement is zero but covered distance is not zero?

I. If a boy starts its journey on a straight line from point A to B such then $\overline{AB} = 5m$ and comes back from point B to A then its displacement is zero because starting and ending point is same but distance is 5+5=10m.

II. When boy completes his journey along circular path then his displacement is zero but distance is not zero.



(iii) A stone tied to string is whirling in circle, what is direction of its velocity at any instant?

A stone is tied to a string and it is moving in a circular path. The instantaneous velocity of stone is acting as tangent to the circle. That is the direction of velocity is perpendicular to the direction of centripetal force.

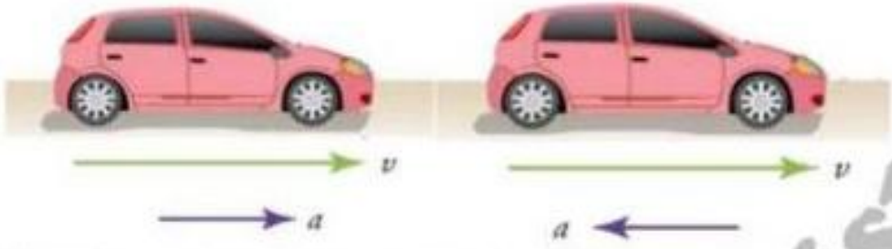
(iv) Is it possible to accelerate an object without speeding it up or slowing it down?

Yes, an object can be accelerated without speeding up or slowing down. We know that acceleration is referred as the rate of change of velocity and the velocity is the speed in a particular direction and is a vector quantity. So, if

the velocity can either changes its speed or direction, there is some acceleration. Thus, if we change the direction, and not the speed, we are still accelerating. Hence, an object in uniform circular motion is accelerating but its speed neither decreases not increases.

(v) Can a car moving towards right have direction of acceleration towards left?

If a car is moving towards right then direction of velocity and acceleration is same i.e. toward the right. We apply brakes on the car then its speed decreases and declaration is produced in it. In this case the direction of velocity is towards the right but the direction of acceleration is towards the left.



(vi) With the help of daily life examples, tell the situations in which

a. acceleration is in the direction of motion

b. acceleration is against the direction of motion

c. acceleration is zero and body is in motion

a. If a car is moving on a straight line with increasing speed then the acceleration is in the direction of motion.

b. When we apply brakes then the speed of the car decreases and deceleration is produced. In this case the acceleration is against the direction of motion.

c. If the car is moving with uniform speed then its velocity does not change with time. So the acceleration is zero but the car is in motion.

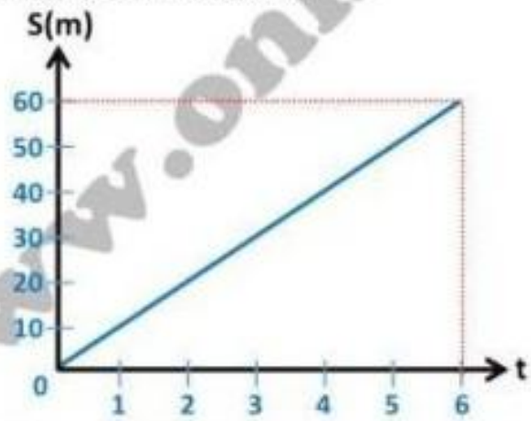
(vii) Examine distance-time graph of a motorcycle (as shown), what does this graph tell us about the speed of motorcyclist? Plot the velocity-time graph for it?

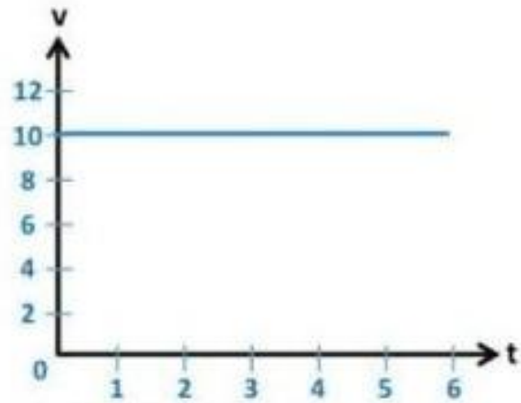
The distance-time graph shows a straight line which means the motorcycle covers equal distance in equal interval of time.

If an object covers equal distance in equal intervals of time then the velocity of the body is called uniform velocity.

$$v = \frac{\Delta S}{\Delta t} = \frac{60 - 0}{6 - 0} = \frac{60}{6} = 10 ms^{-1}$$

So, velocity-time graph of the motorcycle is a line parallel to time axis. Which indicates the uniform velocity as it has same velocity at all the points.





(viii) Which controls in the car can produce acceleration or deceleration in it?

If the speed of a car is increasing then it is called acceleration. We use accelerator to increase the speed of the car which produces acceleration.

If the speed of the car is decreasing then it is called deceleration. We use brakes to decrease the speed of the car which produces deceleration in the car.

(ix) If two stones of 10kg and 1kg dropped from a 1km high tower. Which will hit the ground with greater velocity? Which will hit the ground first? (Neglect the air resistance)

If two stones of 10kg and 1kg dropped from a 1km high tower then the heavier stone will hit the ground the with greater velocity. Because the force with which Earth attract the body towards its centre is equal to the weight of the object. So the stone having mass 10kg will hit the ground with greater velocity.

If we neglect air resistance then both the stones will reach on the ground at same time.

(x) A 1kg ball is dropped (from rest) and another is thrown downward with velocity of $5ms^{-1}$, which will have greater acceleration? (Neglect the air resistance)

The acceleration due to gravity is the same no matter the speed is. But the air resistance is higher, the faster you go.

So the net acceleration of the ball that starts off faster will be less than the acceleration of the one you just dropped until they each reach "terminal velocity" and then neither of them will be accelerating.

NUMERICAL PROBLEMS

Q. Solve the following numerical questions.

1. Convert the following:

a. $36kmh^{-1}$ into ms^{-1}

$$= 36kmh^{-1}$$
$$= \frac{36 \times 1000}{60 \times 60} ms^{-1}$$
$$= \frac{36000}{3600} ms^{-1}$$
$$= 10ms^{-1}$$

b. $120ms^{-1}$ into kmh^{-1}

$$= 120ms^{-1}$$
$$= \frac{120 \times 3600}{1000} kmh^{-1}$$
$$= \frac{432000}{1000} kmh^{-1}$$
$$= 432kmh^{-1}$$

c. $10kmh^{-2}$ into ms^{-2}

$$= 10kmh^{-2}$$
$$= \frac{10 \times 1000}{3600} ms^{-2}$$
$$= \frac{10000}{3600} ms^{-2}$$
$$= 2.7ms^{-2}$$

d. $1ms^{-2}$ into kms^{-2}

$$= 1ms^{-2}$$
$$= \frac{1}{1000} kms^{-2}$$
$$= 0.001kms^{-2}$$

2. A morning walker completes one lap on a 628m long circular track. If the beginning and ending positions are the same, calculate the distance and displacement he travelled. Determine his average speed and average velocity after he completed the trip in 2 minutes.

Data:

$$s = 628m$$
$$Distance = ?$$
$$Displacement = ?$$

$Speed = ?$
$Velocity = ?$
$t = 2minutes$

Solution:

Distance: As the circular track is 628m long so distance is 628m.

Displacement: As the starting and ending point is same, so displacement is zero.

Speed: $Speed = \frac{distance}{time} = \frac{628}{120} = 5.23ms^{-1}$

Velocity: $velocity = \frac{displacement}{time} = \frac{0}{120} = 0ms^{-1}$

3. **In 10 seconds, a cyclist increases its speed from $5kmh^{-1}$ to $7kmh^{-1}$, while a car moves from rest to $20kmh^{-1}$ in same time. Calculate acceleration of each? Which has greater acceleration?**

Data:

$t = 10s$
$v_i(cyclist) = 5kmh^{-1} = \frac{5\times1000}{3600}ms^{-1} = 1.39ms^{-1}$
$v_f(cyclist) = 7kmh^{-1} = \frac{7\times1000}{3600}ms^{-1} = 1.94ms^{-1}$
$v_i(car) = 0ms^{-1}$
$v_f(car) = 20kmh^{-1} = \frac{20\times1000}{3600}ms^{-1} = 5.5ms^{-1}$
$a_{cyclist} = ?$
$a_{car} = ?$

Solution:

$a = \frac{v_f - v_i}{t}$
$a_{cyclist} = \frac{1.94-1.39}{10}$
$a_{cyclist} = 0.055ms^{-2}$
$a = \frac{v_f - v_i}{t}$
$a_{car} = \frac{5.5-0}{10}$
$a_{car} = 0.55ms^{-2}$

Acceleration of the car is greater then the cyclist.

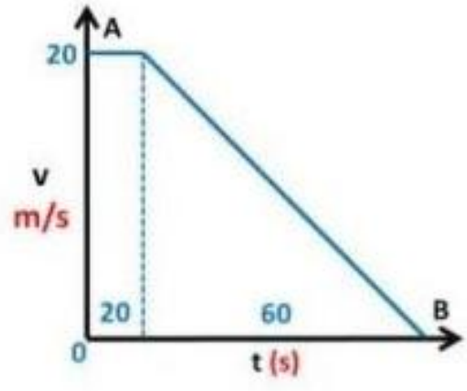
4. **A car moving with uniform velocity of $20ms^{-1}$ for 20 seconds. Then brakes are applied and it comes to rest with uniform deceleration in 1 minute.**
   a. Calculate the total distance covered by car using mathematical equation?
   b. Plot the graph to calculate this distance using speed time graph?

Data:

$v_i = 20ms^{-1}$
$t_1 = 20s$
$v_f = 0ms^{-1}$
$t_2 = 1min = 60s$
$S = ?$
$d\ from\ graph = ?$

Solution:

(a) $S_1 = vt$
$S_1 = (20)(20)$
$S_1 = 400m$
$a = \frac{v_f - v_i}{t} = \frac{0-20}{60} = -\frac{20}{60} = -0.3333ms^{-2}$
$2aS_2 = v_f^2 - v_i^2$
$2(-0.3333)S_2 = (0)^2 - (20)^2$
$-0.6666S_2 = -400$



$$S_2 = \frac{400}{0.6666}$$
$$S_2 = 600m$$
$$S = S_1 + S_2$$
$$S = 400 + 600$$
$$S = 1000m$$

(b) $Total\ distance = Area\ under\ the\ graph$

$$S = Area\ of\ rectangle + Area\ of\ triangle$$
$$S = (Base \times height) + \left(\frac{1}{2}(Base \times height)\right)$$
$$S = (20 \times 20) + \frac{1}{2}(60 \times 20)$$
$$S = 400 + 600$$
$$S = 1000m$$

5. A car starts its motion and accelerates at rate of $2ms^{-2}$. Find its velocity after covering distance of $500m$.

Data:

$$v_i = 0$$
$$a = 2ms^{-2}$$
$$v_f = ?$$
$$S = 500m$$

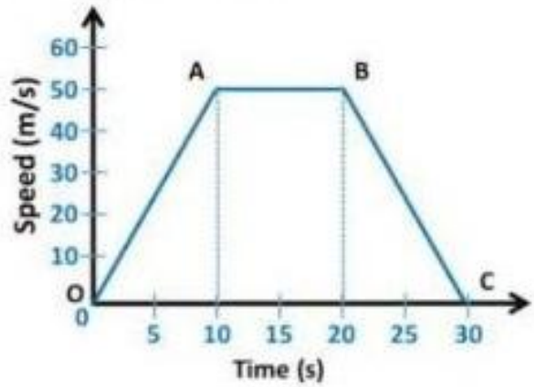
Solution:

$$2aS = v_f^2 - v_i^2$$
$$2(2)(500) = v_f^2 - 0^2$$
$$2000 = v_f^2$$
$$v_f = 44.7ms^{-1}$$

6. Consider the following speed time graph. Tell:

a. Which part of the graph is showing acceleration, deceleration and zero acceleration?

b. Calculate covered distance from 10 seconds to 20 seconds from the graph.



Solution:

(a) At part OA Speed is increasing so it shows acceleration.
At part BC Speed is decreasing so it shows deceleration.
At part AB the speed is constant so it shows zero acceleration.

(B) Part AB shows time from 10 seconds to 20 seconds, so

$$Distance = Area\ under\ AB$$
$$Distance = Area\ of\ rectangle$$
$$Distance = 50 \times 10$$
$$Distance = 500m$$

7. If a ball is dropped from a high building and it reaches ground in 5 seconds. Find the velocity with which it hits the ground? What is its average speed? What is the height of the building?

Data:

$$v_i = 0$$
$$t = 5s$$
$$v_f = ?$$
$$v_{av} = ?$$
$$h = ?$$

Solution:

$$v_f = v_i + gt$$
$$v_f = 0 + (10)(5)$$
$$v_f = 50ms^{-1}$$

$$v_{av} = \frac{v_i + v_f}{2}$$
$$v_{av} = \frac{0+50}{2}$$
$$v_{av} = 25ms^{-1}$$
$$h = v_i t + \frac{1}{2}gt^2$$
$$h = (0)(5) + \frac{1}{2}(10)(5)^2$$
$$h = 0 + 125m$$
$$h = 125m$$

8. **A ball is thrown upward with the velocity of 20m/s from ground.**
   a. In how much time, will it reach the top of its path?
   b. It falls back on ground, what is total time of its trip?
   c. How high will it rise?

Data:

$v_i = 20ms^{-1}$
$v_f = 0$
$g = -10ms^{-2}$
$t = ?$
$t' = ?$
$h = ?$

Solution:

$$v_f = v_i + gt$$
$$0 = 20 + (-10)t$$
$$-20 = -10t$$
$$t = \frac{20}{10}$$
$$t = 2s$$
$$t' = t\,(upward) + t(dowward)$$
$$t' = 2 + 2$$
$$t' = 4s$$
$$h = v_i t + \frac{1}{2}gt^2$$
$$h = (20)(2) + \frac{1}{2}(-10)(2)^2$$
$$h = 40 - 20$$
$$h = 20m$$

Chapter#3

DYNAMICS

MULTIPLE CHOICE QUESTIONS

1. Choose the best possible option.

(i) Which quantity is measure of inertia of a body?

(a) mass ✓ (b) force (c) weight (d) friction

(ii) A force of 5N is applied to a body weighting 10N. What is its acceleration in ms^{-2}?
(a) 0.5 (b) 2 (c) 5 ✓ (d) 50

(iii) If a steel cube has acceleration $10ms^{-2}$. Another same steel cube is plugged into it. What is acceleration of this combination?
(a) $10ms^{-2}$ (b) $5ms^{-2}$ ✓ (c) $1ms^{-2}$ (d) zero

(iv) SI unit of linear momentum is
(a) $kg/m\,s$ (b) kgm^2/s (c) Nm (d) kgm/s ✓

(v) The molecules of a gas enclosed in a glass vessel at constant temperature is an example of
(a) Force system (b) Inertial system (c) Isolated system ✓ (d) Non-Isolated system

(vi) Change in momentum of a body is equal to
(a) Force (b) (Force)(Time) ✓ (c) Velocity (d) Acceleration

(vii) The time rate of change in momentum of a body falling freely is equal to its
(a) friction (b) momentum (c) velocity (d) weight ✓

(viii) As the rocket moves upwards during its motion, it consumes fuels. Its acceleration goes on:
(a) increasing ✓ (b) decreasing
(c) remains same (d) it moves with uniform velocity

(ix) A book of mass 5kg is placed on the table, what is magnitude of force acting on the book?
(a) 50N ✓ (b) 5N (c) 25N (d) 10N

(x) Taking off rocket can be _____ of motion.
(a) 1st law (b) 2nd law (c) 3rd law ✓ (d) 4th law

(xi) Net force on the body falling in air with uniform velocity is equal to
(a) weight of the body (b) air resistance on the body
(c) difference of weight of body and air resistance on it (d) zero ✓

(xii) A small sports car collides head-on with a massive truck. Which vehicle experiences the greater impact force (in magnitude)?
(a) the car (b) the truck
(c) they experience the same force ✓ (d) it depends upon the speed of the vehicle

(xiii) A force acts on a body for 2 seconds and it produces 50kgm/s change in its momentum. The force acting on the body is:
(a) 100N (b) 50N (c) 25N ✓ (d) 2N

(xiv) A body is moving on a straight line and you apply a force, perpendicular to its motion:
(a) body speeds up (b) body slows down
(c) body moves in circle ✓ (d) body moves in the direction of force

(xv) When a hanging carpet is beaten by stick. Dust flies off the carpet. It is mainly due to:
(a) action force on carpet (b) reaction force by carpet
(c) inertia of dust ✓ (d) rate of change of momentum of carpet

(xvi) A bucket having some water is revolved in vertical circle. Water does not spill out, even the bucket is upside down, due to:
(a) weight of water (b) centrifugal force on water ✓
(c) Inertia of water (d) action and reaction balance each other

(xvii) A block of mass 10kg is hanging by string, how much tension is produced in string?
(a) 10N (b) 100N ✓ (c) 1N (d) 50N

(xviii) The force which moves the car is:
(a) force developed by engine (b) force of friction between road and tyre ✓
(c) weight of car (d) water spilt on the road

(xix) Net force on the body falling in air with uniform velocity is equal to
(a) weight of the body (b) air resistance on the body
(c) difference of weight of body and air resistance on it (d) zero ✓

EXERCISE QUESTIONS

2. Give a short response to the following questions

(i) When a motor cyclist hits a stationary car, he may fly off the motor cycle and driver in the car may get neck injury. Explain

When a motor cyclist hits a stationary car then he cannot stop himself due to inertia and continue his state of motion so he may fly off the motor cycle.

While the driver in the car is at rest. When the motor cyclist hits the car then the upper part of the driver wants to stay at rest due to inertia, but his lower part moves with the car with a force produced of collision. So the driver in the car may get neck injury.

(ii) In autumn, when you shake a branch, the leaves get detached. Why does this happen?

In autumn, when we shake a branch, the leaves get detached. Because when a tree is forcefully shaken, the branches of the tree come in motion but the leaves tend to continue in their state of rest due to inertia. As a result of this, leaves get separated from the branches of the tree and hence fall down.

(iii) When a car takes a turn, the passengers experience a force acting on them away from the center of curve, why?

When a car takes a turn then centripetal force is produced which keeps the car to move in a circle. But according to Newton third law of motion, in reaction of this force centrifugal force is also produced. Due to which passengers experience a force acting on them away from the centre of curve.

Secondly as the car takes the turn, according to inertia they will continue their motion is straight path and that's why they are directed away from the centre of curve instead of going towards it.

(iv) Why it is not safe to apply brakes only on the front wheel of a bicycle?

If we apply brakes only on the front wheel of a bicycle then the bike lifts the rear wheel which may cause of an accident. It is due to inertia that the rear wheel wants to continue its motion but when we brake, our weight is being shifted towards the front wheel. The inertia coupled with gravity puts our weight and that of the bike onto the front wheel. More weight means more friction/grip with the ground.

So the front wheel stops immediately, but rear wheel lifts up which may cause of an accident.

(v) Deduce Newton's first law of motion from Newton's second law of motion.

According to Newton's 2nd law

$$F = ma$$

$$F = m\left(\frac{v_f - v_i}{t}\right)$$

If $F = 0$ then $v_i = v_f$ i.e. the object continues to move with uniform velocity if no net force is applied.

If $F = 0$ & $v_i = v_f$, then v_f is also 0. i.e. the object will stay at rest.

According to Newton's 1st law of motion, an object at rest or uniform motion tends to remain at rest or in uninform motion unless an external applied on it.

Hence proved

(vi) Action and reaction are equal but opposite in direction. These forces always act in pair. Do they balance each other? Can bodies move under action-reaction pair?

Balanced forces are equal and opposite forces that act on the same object. That's why they cancel out. Action and reaction forces are equal and opposite forces that act on different objects, so they don't cancel out.

No, a body cannot move under action-reaction pair. For example book lying on the table has weight downward but the table has normal reaction force in upward direction.

(vii) A man slips on the oily floor, he wants to move out of this area. He is alone. He throws his bag to move out of this slippery area. How can this act help him?

When a man slips on the oily floor then he has minimum friction between floor and his feet. He throws his bag to move out of this slippery area. When he throws a bag in one direction then this is an action, according to third law of motion as a reaction he will move in opposite direction due to less friction. This act helps him to move out from the oily floor.

(viii) How would you use Newton's 3rd law of motion and law of conservation of momentum to explain motion of rocket?

Newton's third law of motion states that to every action there is an equal and opposite reaction. Similarly, when a rocket moves, it exerts the action force on the gases to expel them backwards which in turn exerts an equal and opposite reaction force to move the rocket forward.

Rocket works on the principle of conservation of momentum. Rocket eject gases in backward direction which creates momentum of the gases backwards and thus by conservation of momentum, the rocket gets momentum in the forward direction making it move forward.

(ix) Why are batsman gloves padded with foam?

Batsman gloves are padded with foam for protection and it provides better friction between the gloves and the bat instead of using cotton.

Foam and cotton are the types of materials that are used in the finger padding of batting gloves. Despite being lightweight, foam offers the same level of protection as cotton padding. Batsman can better hold the bat due to the finger cutouts, which add extra wrap around the handle due to enough friction between gloves and bat.

(x) While walking on ice, one should take small steps to avoid slipping. Why?

To avoid slipping one should take smaller steps because the friction coefficient of ice is small. So we didn't get enough friction by the ice.

Smaller steps will give larger normal force and more the normal force will give more friction and hence we get sufficient friction to avoid slipping

(xi) "Slippery when wet", it is precaution displayed on motorways. Why is it dangerous to drive on wet roads?

"Slippery when wet", it is precaution displayed on motorways. The biggest hazard of driving on wet roads is the loss of grip or friction. When roads are dry they have enough friction between road and tyre. When a road is wet, the surface of the road becomes smoother which means lack of friction between road and tyres. So when the car is moving and we apply brakes then the brakes will not work properly due to lack of friction which may cause of an accident.

(xii) Why tyres of vehicles are wrapped with chains during snow in Murree hill areas?

Tyres of vehicles are wrapped with chains during snow in Murree hill areas because Snow chains work simply by increasing the amount of grip or friction that tyres have on the roads when they are icy or covered in snow. Increasing the friction between the car and the road makes driving much safer as it reduces the chance of cars losing control and skidding on icy surfaces.

(xiii) Centripetal force acting on the car moving at a roundabout is 200N. If velocity of the car is doubles then what will be centripetal force acting on the car?

Data:

$$F_c = 200N$$
$$v' = 2v$$
$$F_c' = ?$$

Solution:

$$F_c = \frac{mv^2}{r}$$
$$F_c' = \frac{mv'^2}{r}$$
$$F_c' = \frac{m(2v)^2}{r}$$
$$F_c' = \frac{m4v^2}{r}$$
$$F_c' = 4\left(\frac{mv^2}{r}\right)$$
$$F_c' = 4F_c$$

Hence, if the velocity of the car is doubled then centripetal force increases by 4 times.

(xiv) Your car is truck in mud track, two men sit on the bonnet of your car. This helps you to take your car out of mud. How sitting of men on car's bonnet did help you?

Car stuck in mud track, two men sit on the bonnet to increase its friction. This will help to take the car out of mud.

When the car stuck in wet mud the friction between tyres and mud decreases due to which car cannot move. So two men sit on the bonnet or the car to increase the normal force (F_n). Then the friction also increases which will help to take the car out of the mud.

NUMERICAL PROBLEMS

Q. Solve the following numerical questions.

1. A vehicle is accelerating at $5ms^{-2}$ under the action of $2500N$ force, what is mass of the vehicle?

Data:

$a = 5ms^{-2}$
$F = 2500N$
$m = ?$

Solution:

$F = ma$
$m = \frac{F}{a}$
$m = \frac{2500}{5}$
$m = 500kg$

2. A boy is holding a book of mass $2kg$. How much force is he applying on the book? If he moves it up with acceleration of $3ms^{-2}$, How much total force should be apply on the book?

Data:

$m = 2kg$
$F = ?$
$a = 3ms^{-2}$
$F_t = ?$

Solution:

$F = W$
$F = mg$
$F = (2)(9.8)$
$F = 19.6N$
$F = ma$
$F = (2)(3)$
$F = 6N$
$F_t = 19.6 + 6$
$F_t = 25.6N$

3. A girl of mass $30kg$ is running with velocity of $4ms^{-1}$. Find her momentum.

Data:

$m = 30kg$
$v = 4ms^{-1}$
$P = ?$

Solution:

$P = mv$
$P = (30)(4)$
$P = 120Ns$

4. A 2kg steel ball is moving with speed of $15ms^{-1}$. It hits with bulk of sand and comes to rest in 0.2 second. Find force applied by sand bulk on the ball.

Data:

$m = 2kg$
$v_i = 15ms^{-1}$
$v_f = 0$

$t = 0.2s$

$F = ?$

Solution:

$a = \frac{v_f - v_i}{t}$

$a = \frac{0-15}{0.2}$

$a = -\frac{15}{0.2}$

$a = -75ms^{-2}$

$F = ma$

$F = (2)(75)$

$F = 150N$

5. **A soccer player kick the football with force of 1200N with impact time of 0.60 second. Find the change in momentum of football?**

Data:

$F = 1200N$

$t = 0.60s$

$\Delta P = ?$

Solution:

$F = \frac{\Delta P}{t}$

$\Delta P = Ft$

$\Delta P = (1200)(0.60)$

$\Delta P = 720Ns$

6. **A 100 grams bullet is fired from $5kg$ gun. Muzzle velocity of bullet is $20ms^{-1}$. Find recoil velocity of the gun.**

Data:

$m = 100g = 0.1kg$

$M = 5kg$

$v = 20ms^{-1}$

$V = ?$

Solution:

According to law of conservation of momentum

$MV = mv$

$V = \frac{mv}{M}$

$V = \frac{(0.1)(20)}{5}$

$V = 0.4ms^{-1}$

7. **A robotic car of $15kg$ is moving with $25ms^{-1}$. Brakes are applied to stop it. Brakes apply constant force of $50N$. How long does the car take to stop?**

Data:

$m = 15kg$

$v = 25ms^{-1}$

$F = 50N$

$t = ?$

Solution:

$F = \frac{\Delta P}{t}$

$F = \frac{mv}{t}$

$t = \frac{mv}{F}$

$t = \frac{(15)(25)}{50}$

$t = 7.5s$

8. **A force of $20N$ is applied on stack of books of mass 3kg to push it on a rough table surface with uniform speed of $20ms^{-1}$. How much net force is acting on it? What is the value of friction between the stack of books and the table surface?**

Data:

$F = 20N$
$m = 3kg$
$v = 20ms^{-1}$
$F_{net} = ?$
$f = ?$

Solution:

As the speed is uniform in straight line then velocity would be zero. Which mean zero acceleration. So net force

$F_{net} = ma$
$F_{net} = (3)(0)$
$F_{net} = 0N$

The friction and the force applied must be equal in magnitude and opposite in direction. Therefore frictional force

$f = 20N$

9. **A wooden block of mass $50kg$ is placed on the rough surface of table. What is the weight of the block? What is normal force on the block by table? If coefficient of static friction between the block and the table is 0.4, find the minimum force to move the block on the table.**

Data:

$m = 50kg$
$W = ?$
$F_n = ?$
$\mu = 0.4$
$F = ?$

Solution:

$W = mg$
$W = (50)(9.8)$
$W = 490N$
$F_n = W$
$F_n = 490N$
$F = \mu mg$
$F = (0.4)(50)(9.8)$
$F = 196N$

10. **A cyclist weighing 500N is moving in circular track of radius 60 metres with a uniform speed of $12ms^{-1}$. Find the centripetal force required to keep him moving in this circular track.**

Data:

$W = 500N$
$r = 60m$
$v = 12ms^{-1}$
$F_c = ?$

Solution:

$W = mg$
$m = \frac{W}{g}$
$m = \frac{500}{9.8}$
$m = 51kg$
$F_c = \frac{mv^2}{r}$

$F_c = \frac{(51)(12)^2}{60}$

$F_c = \frac{7344}{60}$

$F_c = 122.4N$

11. A stone of 500g tied to a string of length 50cm is whirled by a girl in a horizontal circle with speed of $3ms^{-1}$. Find the tension in the string. Also tell which force is responsible to produce tension in the string?

Data:

$m = 500g = 0.5kg$

$r = 50cm = 0.5m$

$v = 3ms^{-1}$

$T = ?$

Solution:

$T = F_c = \frac{mv^2}{r}$

$T = \frac{(0.5)(3)^2}{0.5}$

$T = 9N$

Centripetal force is responsible to produce tension in the string.

12. Two bodies of mass 10kg and 8kg hanging by string that is passing over frictionless pulley. Both bodies move vertically on releasing them. Find the acceleration of the system and tension produced in the string?

Data:

$m_1 = 10kg$

$m_2 = 8kg$

$a = ?$

$T = ?$

Solution:

$a = \frac{(m_1 - m_2)}{(m_1 + m_2)} \times g$

$a = \frac{(10 - 8)}{(10 + 8)} \times 10$

$a = \frac{2}{18} \times 10$

$a = 1.11ms^{-2}$

$T = \frac{2m_1m_2}{m_1 + m_2} \times g$

$T = \frac{2(10)(8)}{10 + 8} \times 9.8$

$T = \frac{160}{18} \times 9.8$

$T = 87.1N$

13. Find acceleration due to gravity using Atwood machine having mass 5kg and 3kg if system has acceleration of $2ms^{-2}$.

Data:

$g = ?$

$m_1 = 5kg$

$m_2 = 3kg$

$a = 2ms^{-2}$

Solution:

$a = \frac{(m_1 - m_2)}{(m_1 + m_2)} \times g$

$g = \frac{(m_1 + m_2)}{(m_1 - m_2)} \times a$

$$g = \frac{(5+3)}{(5-3)} \times 2$$
$$g = \frac{8}{2} \times 2$$
$$g = 8ms^{-2}$$

Chapter#4

TURNING EFFECT OF FORCES

MULTIPLE CHOICE QUESTIONS

1. Choose the best possible option.

(i) Torque applied on a wheel is product of force and momentum arm. The moment arm is:
(a) The perpendicular distance between the line of action of force and axis of rotation. ✓
(b) The shortest distance between force and its acceleration
(c) Any length between axis of rotation and force
(d) Displacement vector parallel to force

(ii) Torque acting on a football is _____ if the line of action of the applied force passes through its center of mass
(a) Maximum (b) Minimum (c) Zero ✓ (d) 1

(iii) If the body is at rest or moving with uniform rotational velocity, torque acting on the body will be
(a) Maximum (b) Minimum (c) zero ✓ (d) Infinite

(iv) Two equal and opposite forces acting at different points on a body form
(a) Pair of forces (b) Couple ✓ (c) net force (d) Duo

(v) According to the first condition of equilibrium, the vector sum of all the forces acting on a body must be
(a) Negative (b) Positive (c) Zero ✓ (d) Constant but non 0

(vi) If the body is moving with uniform velocity or rotating with uniform rotational velocity, it is said to be in
(a) Static equilibrium (b) Dynamic equilibrium ✓ (c) Both A and B (d) non equilibrium

(vii) A boy exerts force on a body, that moves without rotation. The location on the body where force is applied, is known as
(a) Midpoint (b) Centre of gravity (c) Center of mass ✓ (d) all of these

(viii) If x and y component of force are 5N and 12N respectively. The magnitude of force is
(a) 5N (b) 13N ✓ (c) 17N (d) 7N

(ix) A body in equilibrium must not have
(a) speed (b) quantity of motion (c) velocity (d) acceleration ✓

(x) You are trying to loosen a nut with a spanner but it is not happening. What would you do to loosen the nut
(a) Insert a pipe to increase length of spanner ✓ (b) Use a spanner of small length
(c) Use plastic and soft spanner (d) Tie a rope with spanner

(xi) A boy weighing 500N is sitting on edge of one side of seesaw at distance of 3m from center. A girl weighing 600N is sitting at 2m from the centre of seesaw.
(a) Side of girl will move downward (b) Side of boy will move downward ✓
(c) Seesaw is in horizontal state (d) Net torque is 200Nm

(xii) A force of 10N is acting along y axis, what is its horizontal component?
(a) 10N (b) 0 ✓ (c) 5N (d) value from 0N to 10N

CONCEPTUAL QUESTIONS

2. Give a short response to the following questions

(i) Two forces of 7N and 5N are added, how will they give resultant of 12N and 2N?

Two forces 7N and 5N has a resultant of 12N if they have same direction and parallel to each other.

Two forces 7N and 5N has a resultant of 2N if they have opposite direction and parallel to each other.

(ii) Why long spanner is used to open or tight nuts of vehicle's tyre? While tightening a small nut, extra-long wrench is not suitable. Why?

A long spanner provides a greater moment of force than a short one hence less force is applied. That's why long spanner is used to open or tight nuts of vehicle's tyre.

If we use such a large wrench for tightening a small bolt, a large torque will produce. This may damage or break the bolt. So extra-long wrench is not suitable for tightening a small nut.

(iii) Why door knobs are fixed at the edge of door? What will happen if the door knob is at the middle of the door?

Door knobs are fixed at the edge of door because doors are opened through the application of torque. To make it as easy as possible to open the door, the knobs are placed as far from the hinge as is feasible. This maximizes the lever arm, reducing the amount of force needed to open the door.

If the door knob is at the middle of the door then greater force is required as compared to the door knob at the edge of the door. Because the knob at the middle of the door decreases the moment arm which means greater force is required to open the door.

(iv) A uniform metre rod is balanced on the sharp edge of a knife. A mass is hanging on its right side. Why is it not falling on right side?

We can see that a mass is hanging with a rod and the rod also has a mass. As torque depends upon force and moment arm so in this case the clockwise torque produced on right side is equal to the anti-clockwise torque produced on the left side of the knife. These two torques are equal so the uniform metre rod is balanced on the sharp edge of a knife.

(v) How does this toy remain balanced on finger, even disturbed slightly?

Balancing bird remain balanced on finger, even disturbed slightly because of the way that the balancing bird is spreading its wings, it is able to distribute its weight in such a way that it creates a center of gravity right below the beak. The Centre of gravity is an imaginary point in a body of matter where the total weight of the body is thought to be concentrated. Having the center of gravity below the beak allows the bird to be balanced on a finger.

(vi) A small boy is thrown straight up by his father. At the top of his path, he comes to rest for a moment. Will he be in equilibrium at this point?

A small boy is thrown straight up by his father. At the top of his path, only velocity is zero but the acceleration due to gravitational force is acting downward continuously.

For a body to be in equilibrium, some of all the force acting on the body must be equal to zero. So the small boy is not in an equilibrium. As you can see, it will fall under gravity and not stay in the air. If the small boy was in an equilibrium, it would not fall under gravity. Of course, that would never happen.

(vii) A fan is rotating uniformly, is it in equilibrium?

If a body is at rest or moving with uniform velocity then the body is in equilibrium. As the fan is rotating uniformly so it is in equilibrium.

(viii) Can a body be in equilibrium under the action of single force or single torque?

For a body to be in complete equilibrium, the sum of all the forces and some of all the torques acting on the body must be equal to zero.

A body cannot be in the state of equilibrium if only a single force acts on it because we need two or more forces equal in magnitude but opposite in direction to cancel out each other.

Since single torque can never be zero and rotational acceleration will be produced. Therefore we can say that a body cannot be in equilibrium under the action of single torque.

(ix) Give an example of a body, which satisfies first condition of equilibrium but it is not in equilibrium?

A pendulum at its extreme positions are not in equilibrium but under the action of the force of gravity.

(x) Why Heavy Transport Vehicles (HTV) are made at their bottom?

Heavy Transport Vehicles (HTV) are made heavy at its bottom so that to keep its centre of gravity as low as possible.

A lower center of gravity helps to keep the Heavy Transport Vehicles stable. Moreover, the base is made wide so that the vertical line passing through the centre of the gravity should not get out of its base during a turn.

(xi) A boy standing by joining both legs is more likely to fall than a boy standing with legs wide open. If slightly pushed by another boy. Why?

A boy standing by joining both legs is in state of unstable equilibrium. If he is slightly pushed by another boy then his canter of mass falls when it is displaced, and he will not come to its original position. Hence he may fall down.

While a boy standing with open legs is in state of stable equilibrium. If he is slightly pushed by another boy then his center of mass rises when it is displaced, and he comes back to its original position. Hence he may not fall.

NUMERICAL PROBLEMS

Q. Solve the following numerical questions.

1. **Find the magnitude and direction of the resultant of these forces acting on a block:**

   A. 70N along x axis B. 50N at 30° with x axis C. 40N along y axis

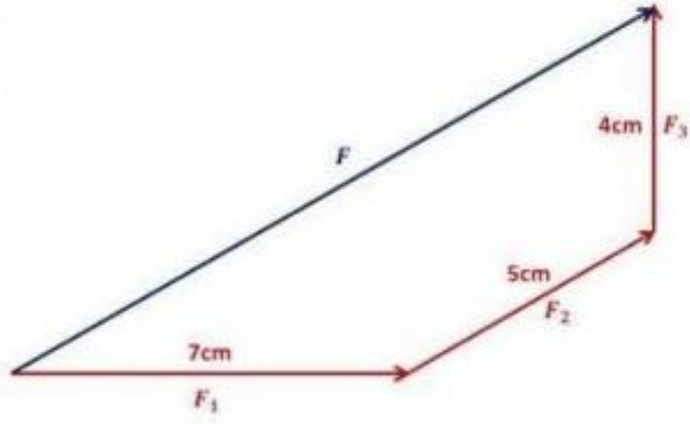
Data:

$F_1 = 70N \ along \ x-axis$

$F_2 = 50N \ at \ 30° \ with \ x-axis$

$F_3 = 40N \ along \ y-axis$

$F = ?$



Solution:

$Scale = 10N = 1cm$

By using scale.

$F = 13.06cm$

$F = 13.06 \times 10$

$F = 130.6N$

By using protector

$\theta = 29.8°$

2. **An aeroplane is moving with 200m/s at angle of 60° with horizontal. Sun is shining straight above the aeroplane. What is speed of shadow of the plane on ground.**

Data:

$v = 200ms^{-1}$

$\theta = 60°$

$Speed\ of\ shadow = ?$

Solution:

$F_x = Fcos\theta$

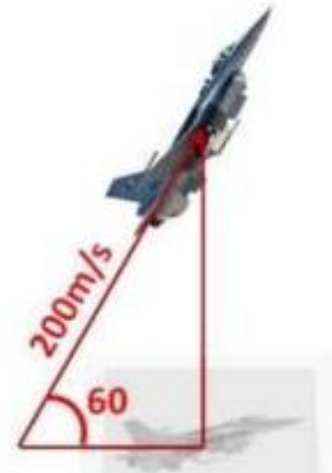
$F_x = 200cos60$

$F_x = 200(0.5)$

$F_x = 100$

$Speed\ of\ shadow\ is\ 100ms^{-1}$

3. **70N force is acting on a body at 60° with the horizontal. Find the magnitude of its components.**



Data:

$F = 70N$

$\theta = 60°$

$F_x = ?$

$F_y = ?$

Solution:

$F_x = Fcos\theta$

$F_x = 70cos60$

$F_x = 70 \times 0.5$

$F_x = 35N$

$F_y = Fsin\theta$

$F_y = 70sin60$

$F_y = 70 \times 0.866$

$F_y = 60.62N$

4. **The horizontal and the vertical components of a force are 3N and 4N respectively. Find their resultant force.**

Data:

$F_x = 3N$

$F_y = 4N$

$F = ?$

Solution:

$F = \sqrt{F_x^2 + F_y^2}$

$F = \sqrt{3^2 + 4^2}$

$F = \sqrt{9 + 16}$

$F = \sqrt{25}$

$F = 5N$

$\theta = tan^{-1}\frac{F_y}{F_x}$

$\theta = tan^{-1}\frac{4}{3}$

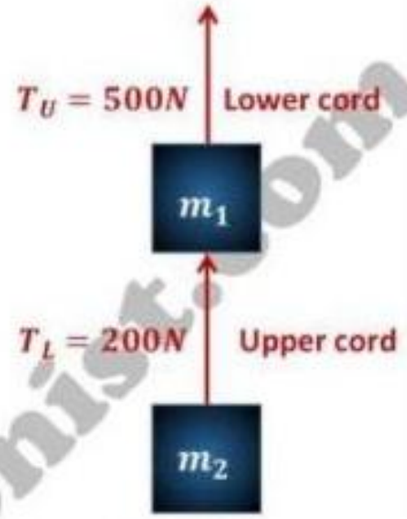
$\theta = tan^{-1}1.33$

$\theta = 53°$

5. **Two bodies are hanging by two cords of ropes as shown. Tension in upper cord is 500N and lower cord is 200N. Find the masses of bodies.**

Data:

$T_U = 500N$
$T_L = 200N$
$m_1 = ?$
$m_2 = ?$



Solution:

$W = mg$
$W = m_1 g$
$m_1 = \frac{W}{g} = \frac{T_U - T_L}{g}$
$m_1 = \frac{500-200}{10}$
$m_1 = 30kg$
$W = m_2 g$
$m_2 = \frac{W}{g} = \frac{T_L}{g}$
$m_1 = \frac{200}{10}$
$m_1 = 20kg$

6. **Calculate the torque acting on a spanner of length 20cm to loosen a nut by a force of 50N. If the same nut is to loosen up by the force of 100N, what should be the length of spanner?**

Data:

$\tau = ?$
$l_1 = 20cm = 0.2m$
$F_1 = 50N$
$F_2 = 100N$
$l_2 = ?$

Solution:

$\tau = F_1 l_1$
$\tau = (50)(0.2)$
$\tau = 10Nm$
$\tau = F_2 l_2$
$l_2 = \frac{\tau}{F_2}$
$l_2 = \frac{10}{100}$
$l_2 = 0.1m$
$l_2 = 10cm$

7. **If a nut is loosen by 90Nm torque using a spanner of the length 30cm, then how much force is applied on the spanner?**

Data:

$\tau = 90Nm$
$l = 30cm = 0.3m$
$F = ?$

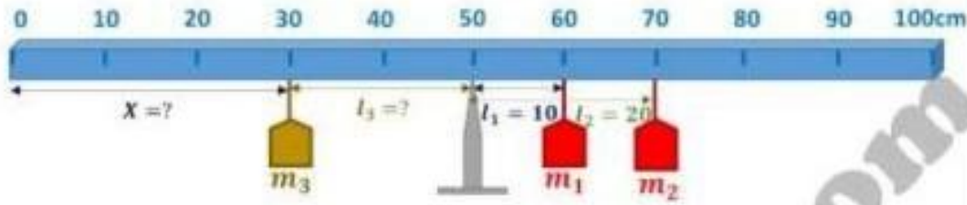
Solution:

$\tau = Fl$
$F = \frac{\tau}{l}$
$F = \frac{90}{0.3}$
$F = 300N$

8. **Two masses 200g and 50g are hanging at positions 60cm and 70cm respectively on a uniform metre rod as shown. Where should the third mass of 150g be positioned to balance this metre rod as shown.**

Data:

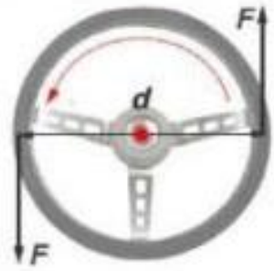
$m_1 = 200g = 0.2kg$
$m_2 = 50g = 0.05kg$
$m_3 = 150g = 0.15kg$
$l_1 = 10cm = 0.1m$
$l_2 = 20cm = 0.2m$
$X = ?$



Solution:

$\tau_{anti-clockwise} = \tau_{clockwise}$
$W_3 l_3 = W_1 l_1 + W_2 l_2$
$m_3 g l_3 = m_1 g l_1 + m_2 g l_2$
$m_3 l_3 = m_1 l_1 + m_2 l_2$
$(0.15) l_3 = (0.2)(0.1) + (0.05)(0.2)$
$0.15 l_3 = 0.02 + 0.01$
$0.15 l_3 = 0.03$
$l_3 = \frac{0.03}{0.15}$
$l_3 = 0.2m$
$l_3 = 20cm$
$X = 50 - l_3$
$X = 50 - 20$
$X = 30cm$

9. A steering wheel of diameter 2 feet is rotated by two equal and opposite forces, each of magnitude 10N. What is couple arm? Calculate the moment of couple.



Data:

$D = 2feet = 60.96cm = 0.61m$
$r = \frac{D}{2} = \frac{0.61}{2} = 0.305m$
$F = 10N$
$couple\ arm = ?$
$moment\ of\ couple\ arm = ?$

Solution:

Moment arm is equal to the perpendicular distance between the lines of action of two forces. i.e. $0.61m$

$moment\ of\ couple\ arm = F \times D$
$moment\ of\ couple\ arm = (10)(0.61)$
$moment\ of\ couple\ arm = 6.1Nm$

Chapter#5

GRAVITATION

MULTIPLE CHOICE QUESTIONS

1. Choose the best possible option.

(i) Two identical balls of masses 1kg, each having distance of 1m between their centers, then gravitational force between them is:

(a) $667 \times 10^{-9}N$ (b) $6.67 \times 10^{-11}N$ ✓ (c) $667 \times 10^{11}N$ (d) $6.67 \times 10^{-13}N$

(ii) The gravitational force between two objects if "F". If masses of bodies are doubled and distance between their centers is reduced to half then gravitational force is:

(a) F (b) 4F (c) F/4 (d) 16F ✓

(iii) The force of gravity applied by Earth on Sun is _____ that of Sun on Earth.

(a) greater than (b) smaller then ✓

(c) sometimes greater or smaller than (d) same as

(iv) The weight of a body on the earth is 100N, what is its weight on the moon?

(a) 10kg (b) 10N (c) 100N (d) 16.67N ✓

(v) The weight of an object is smallest at

(a) poles (b) Murree (c) Moon ✓ (d) Equator

(vi) The value of gravitational field strength near the surface of earth:

(a) $9.8\ N/kg$ ✓ (b) $1.6\ N/kg$

(c) Different for different masses (d) infinity (because all objects fall on earth)

(vii) The GPS satellites system has _____ satellites

(a) 1 (b) 3 (c) 12 (d) 24 ✓

(viii) Two satellites are revolving around the earth in the same orbit, which one will have the greater orbital speed?

(a) heavier satellite (b) lighter satellite

(c) same ✓ (d) controlled by persons on ground

(ix) What will be the effect on orbital velocity of satellite if the mass of Earth increases 4 times but the radius of Earth remains same?

(a) increases 2 times ✓ (b) increases 4 times (c) increases 16 times (d) remains same

(x) At the height equal to two time the radius of earth, the value of g will be

(a) g/9 ✓ (b) g/3 (c) g/4 (d) g

(xi) The value of g decreases with

(a) increase in mass of body (b) falling towards earth surface

(c) decrease in mass of body (d) moving away from earth surface ✓

CONCEPTUAL QUESTIONS

2. Give a short response to the following questions

(i) Newton's law of gravitation suggests that gravitational force acts between any two material objects. Then why two chairs in your room do not attract each other due to this force?

In order to be able to notice the gravitational force of attraction between any two objects, at least one of the objects on the earth should have an extremely large mass. Since no object on the earth have an extremely large mass, we cannot notice such forces.

The two chairs in a room do not move towards each other due to their small masses, the gravitational force of attraction between them is very, very weak.

(ii) Why "G" is called universal gravitational constant?

Universal gravitational constant, G is independent of the nature of the particle, medium between the particles, change in position and time. G is a constant of proportionality and called the universal gravitational constant. Its value remains same everywhere on the earth or in the universe.

Value of $G = 6.67 \times 10^{-11} Nm^2kg^{-2}$

(iii) Why is it difficult to measure the value of "G"?

G is quite difficult to measure because gravity is much weaker than other fundamental forces, and an experimental apparatus cannot be separated from the gravitational influence of other bodies.

The value of G is an extremely small numerical value i.e. $6.67 \times 10^{-11} Nm^2kg^{-2}$. Its smallness accounts for the fact that the force of gravitational attraction is only appreciable for objects with large mass.

(iv) Where will your weight be greater, at Murree hills or at Karachi? Where will your mass be greater?

We know that $W = mg$

Weight of the body depends upon the value of gravitational acceleration g which changes with altitude. As the distance from the Earth increases, the value of g decreases. Murree is at height as compare to Karachi so weight of the body is greater at Karachi then Murree hills.

Mass is constant everywhere. It does not changes with change of place. So mass will same at both places.

(v) If a man travels from the North Pole to the equator, what will be the effect on his weight during this trip?

We know that weight of the body depends upon the value of gravitational acceleration. The value of g is smaller at equator then the poles.

So if a man travels from the North Pole to equator then his weight losses, but the difference is small. Note that the body itself does not change. Rather it is the force of gravity and other forces that change as he approaches the equator. These forces change right back when he return to your original latitude.

(vi) Earth and an apple on a tree attract each other by the force of gravity. The apple falls on earth but why the earth does not move towards apple?

Earth and an apple on a tree attract each other by the force of gravity. The apple falls on earth but the earth does not move towards apple because of mass.

Apple falls towards the earth, but the earth does not move towards the apple because acceleration is inversely proportional to mass. Earth's mass being extremely large as compared to apple, it has negligible acceleration towards the apple. So the apple falls on the earth.

(vii) The mass of moon is 100 times less than the mass of earth and the radius of moon is 4 times less than the radius of earth. Show that value of g is 6 times less than value of g on earth?

Data:

$$M_m = \frac{M_e}{100}$$

$$R_m = \frac{R_e}{4}$$

To Prove:

$$g_m = \frac{g_e}{6}$$

Solution:

$$g_e = \frac{GM_e}{R_e^2}$$

$$g_m = \frac{GM_m}{R_m^2}$$

$$g_m = \frac{G\left(\frac{M_e}{100}\right)}{\left(\frac{R_e}{4}\right)^2}$$

$$g_m = \frac{\frac{GM_e}{100}}{\frac{R_e^2}{16}}$$

$$g_m = \frac{GM_e}{100} \times \frac{16}{R_e^2}$$

$$g_m = \frac{16}{100} \times \frac{GM_e}{R_e^2}$$

$$g_m = \frac{1}{6.2} \times g_e$$

$$g_m = \frac{g_e}{6}$$

Hence proved

(viii) If mass and radius of earth becomes double then what will be the effect on the value of g on the surface of the earth?

We know that

$$g_e = \frac{GM_e}{R_e^2}$$

$$M_e' = 2M_e, \quad R_e' = 2R_e, \quad g_e' = ?$$

$$g'_e = \frac{GM'_e}{R'^2_e}$$
$$g'_e = \frac{G(2M_e)}{(2R_e)^2}$$
$$g'_e = \frac{2GM_e}{4R_e^2}$$
$$g'_e = \frac{1}{2}\frac{GM_e}{R_e^2}$$
$$g'_e = \frac{1}{2}g_e$$

So, if mass and radius of earth becomes double then the value of g reduces to half.

(ix) Artificial satellites do not have engines like cars then how can they keep on moving around the earth?

Artificial satellites do not have engines like cars but they keep on moving around the earth. We know that centripetal force keeps a body to move in a circle. So a satellite rotates around the earth by using earth's gravitational force as centripetal force. Also as there is no air in space, it does not have to work against air resistance. Hence it doesn't lose any energy while rotating.

(x) The orbital speed of a satellite orbiting very close to earth (at negligible height) is "v_o". What will be the orbital speed of another satellite revolving at a height, equal to the radius of earth (in term of orbital speed of close orbiting satellite).

The orbital speed of satellite is given by

$$v_0 = \sqrt{\frac{GM}{R}}$$

Orbital speed at height h is given by

$$v'_o = \sqrt{\frac{GM}{R+h}}$$

As $h = R$ so

$$v'_o = \sqrt{\frac{GM}{R+R}}$$
$$v'_o = \sqrt{\frac{GM}{2R}}$$
$$v'_o = \frac{1}{\sqrt{2}}\sqrt{\frac{GM}{R}}$$
$$v'_o = 0.707\, v_o$$

NUMERICAL PROBLEMS

Q. Solve the following numerical questions.

1. Two identical balls of masses 1000kg each have distance of 50m between their centers. Find the gravitational force between the balls.

Data:

$m_{1=}1000kg$
$m_2 = 1000kg$
$d = 50m$
$F = ?$

Solution:

$$F = \frac{Gm_1m_2}{d^2}$$
$$F = \frac{(6.673 \times 10^{-11})(1000)(1000)}{(50)^2}$$
$$F = \frac{6.673 \times 10^{-5}}{2500}$$

$F = 2.67 \times 10^{-8} N$

2. **Two stars of masses $2 \times 10^{10} kg$ and $4 \times 10^{20} kg$ experience gravitational force of 1000N. Find the separation between the two stars?**

$m_1 = 2 \times 10^{10} kg$
$m_2 = 4 \times 10^{20} kg$
$F = 1000N$
$d = ?$

Solution:

$$F = \frac{Gm_1m_2}{d^2}$$
$$d^2 = \frac{Gm_1m_2}{F}$$
$$d^2 = \frac{(6.673 \times 10^{-11})(2 \times 10^{10})(4 \times 10^{20})}{1000}$$
$$d^2 = \frac{53.384 \times 10^{19}}{1000}$$
$$d^2 = 53.384 \times 10^{19} \times 10^{-3}$$
$$d^2 = 53.384 \times 10^{16}$$
$$d = 7.3 \times 10^{8} m$$
$$d = 7.3 \times 10^{5} km$$

3. **Calculate the value of g at the height of 1500km above the surface of earth?**

Data:

$g = ?$
$h = 1500km = 1500 \times 10^3 m$
$R = 6400km = 6400 \times 10^3 m$
$M_e = 6 \times 10^{24} kg$

Solution:

$$g = \frac{GM_e}{(R+h)^2}$$
$$g = \frac{(6.673 \times 10^{-11})(6 \times 10^{24})}{(6400 \times 10^3 + 1500 \times 10^3)^2}$$
$$g = \frac{40 \times 10^{13}}{(7900 \times 10^3)^2}$$
$$g = \frac{40 \times 10^{13}}{(79 \times 10^5)^2}$$
$$g = \frac{40 \times 10^{13}}{6241 \times 10^{10}}$$
$$g = 0.0064 \times 10^3$$
$$g = 6.4 ms^{-2}$$

4. **A geostationary satellite revolves around the earth in an orbit of the radius 42000km. Find the value of g and orbital speed at this height?**

Data:

$R + h = 42000km = 42000 \times 10^3 m$
$M_e = 6 \times 10^{24} kg$
$G = 6.673 \times 10^{-11} Nmkg^{-2}$
$g = ?$
$v_o = ?$

Solution:

$$g = \frac{GM_e}{(R+h)^2}$$
$$g = \frac{(6.673 \times 10^{-11})(6 \times 10^{24})}{(42000 \times 10^3)^2}$$
$$g = \frac{40 \times 10^{13}}{(42 \times 10^6)^2}$$
$$g = \frac{40 \times 10^{13}}{1764 \times 10^{12}}$$
$$g = 0.0227 \times 10$$
$$g = 0.227 ms^{-2}$$
$$v_0 = \sqrt{\frac{GM}{R+h}}$$
$$v_0 = \sqrt{\frac{(6.673 \times 10^{-11})(6 \times 10^{24})}{(42000 \times 10^3)}}$$
$$v_0 = \sqrt{\frac{40 \times 10^{13}}{(42 \times 10^6)}}$$
$$v_0 = \sqrt{0.952 \times 10^7}$$
$$v_0 = 3085.4 ms^{-1}$$
$$v_0 = 3.0854 \times 10^3 ms^{-1}$$
$$v_0 = 3 kms^{-1}$$

5. Value of g on earth surface is $9.8ms^{-2}$. What is the value of g on a planet whose mass is five times the mass of earth and its radius is twice the radius of earth? What is the weight of 130kg body on this planet?

Data:

$g_e = 9.8ms^{-2}$
$g = ?$
$M = 5M_e = 5 \times 6 \times 10^{24}kg = 30 \times 10^{24}kg$
$R = 2R_e = 2 \times 6.4 \times 10^6 m = 12.8 \times 10^6 m$
$W = ?$
$m = 130kg$
$G = 6.673 \times 10^{-11} Nmkg^{-2}$

Solution:

$$g = \frac{GM}{R^2}$$
$$g = \frac{(6.673 \times 10^{-11})(30 \times 10^{24})}{(12.8 \times 10^6)^2}$$
$$g = \frac{200.19 \times 10^{13}}{163.84 \times 10^{12}}$$
$$g = 1.22 \times 10$$
$$g = 12.2 ms^{-2}$$
$$W = mg$$
$$W = (130)(12.2)$$
$$W = 1586N$$

6. Calculate orbital speed of satellite orbiting around the earth at the height of 6400km?

Data:

$v_o = ?$
$h = 6400km = 6.4 \times 10^6 m$

Solution:

$$v_0 = \sqrt{\frac{GM}{(R+h)}}$$

$$v_0 = \sqrt{\frac{(6.673 \times 10^{-11})(6 \times 10^{24})}{(6.4 \times 10^{6} + 6.4 \times 10^{6})}}$$

$$v_0 = \sqrt{\frac{40 \times 10^{13}}{(12.8 \times 10^{6})}}$$

$$v_0 = \sqrt{3.125 \times 10^{7}}$$

$$v_0 = 5590.1 ms^{-1}$$

$$v_0 = 5.5901 \times 10^{3} ms^{-1}$$

$$v_0 = 5.6 kms^{-1}$$

Chapter#6

WORK AND ENERGY

MULTIPLE CHOICE QUESTIONS

1. Choose the best possible option.

(i) joule (J) is the unit of work which is equal to:
(a) N (b) $kgms^{-2}$ (c) Ws ✓ (d) Ns

(ii) Work done by a body is zero if angle between force and displacement is:
(a) $0°$ (b) $30°$ (c) 60^o (d) $90°$ ✓

(iii) A car, an elephant and a cricket ball have same kinetic energies. Which of these have greater speed?
(a) Car (b) Elephant (c) Cricket ball ✓ (d) All have same speed

(iv) A body of weight 100N is lifted to height 10 metre in 2 second. What is its potential energy?
(a) 100J (b) 2000J (c) 1000J ✓ (d) 500J

(v) If $\theta < 90°$, work done is said to be
(a) Negative (b) Positive ✓ (c) Zero (d) Either +ve or –ve

(vi) Power is a
(a) Scalar quantity ✓ (b) vector quantity (c) fixed quantity (d) fundamentalquantity

(vii) The SI unit of power is
(a) joule (b) watt ✓ (c) newton (d) erg

(viii) A 4kg body is thrown vertically upward from the ground with a velocity of $5ms^{-1}$. If friction is neglected its kinetic energy just before hitting the ground is
(a) 25J (b) 50J ✓ (c) 75J (d) 100J

(ix) A ball is thrown upward with an initial velocity, its
(a) K,E, increases & decreases (c) K.E. decreases & P.E. increases ✓
(c) Both K.E. & P.E. increases (d) Both K.E & P.E decreases

(x) A ball is thrown upward with an initial velocity, its total energy:
(a) is maximum at highest point (b) is minimum at highest point
(c) is maximum when ball is thrown upward (d) remains constant ✓

(xi) K.E and P.E are two basic forms of

(a) Nuclear energy (b) Electric energy (c) Magnetic energy (d) Mechanical energy ✓

(xii) A weight lifter of power 1960 watt lifts a load of mass M from the ground to a height of 2m in 3 seconds. M is

(a) 100kg (b) 200kg (c) 300kg ✓ (d) 400kg

(xiii) According to Einstein's equation ($E = mc^2$), 1kg mass has energy:

(a) $3 \times 10^{16} J$ (b) $9 \times 10^{16} J$ ✓ (c) $9 \times 10^{8} J$ (d) $3 \times 10^{8} J$

(xiv) Which one is renewable source of energy:

(a) coal (b) natural gas (c) sunlight ✓ (d) uranium

(xv) $1hp =$ _____ W:

(a) 756W (b) 716W (c) 736W (d) 746W ✓

CONCEPTUAL QUESTIONS

2. Give a short response to the following questions

(i) Under what condition, work done on the body is maximum and minimum?

Maximum work done: Work done will be maximum if the angle between force and displacement is zero. i.e.

$$W = Fdcos\theta = Fdcos0 = Fd(1) = Fd$$

Minimum work done: Work done will be minimum if the angle between force and displacement is 90. i.e.

$$W = Fdcos90 = Fdcos90 = Fd(0) = 0$$

(ii) Why is only horizontal component of the force acting on the body involved in expression of work?

When force is applied on an object at some angle then the object covers some distance. As the object moves along the horizontal component of the force and not along the vertical component. So, it is only horizontal component of the force $Fcos\theta$ acting on the body that involves in expression of work.

$$W = F_{||}d$$
$$W = (Fcos\theta)d$$
$$W = Fdcos\theta$$

(iii) If a bucket of water having mass of 20kg is carried by a person through distance of 10m, calculate the work done by the person in carrying the bucket.

Data:

$m = 20kg$
$d = 10m$
$W = ?$

Solution:

$W = Fd$
$W = mgd$
$W = (20)(9.8)(10)$
$W = 1960J$

(iv) Give an example of negative work done by a body?

Consider a vehicle is moving rapidly. When we apply breaks on rapidly moving vehicle, the car moves exactly opposite direction to the force. Here the force is trying to stop the vehicle and its direction is opposite to the displacement. As the force and displaced are antiparallel to each other having angle of 180° So work is negative.

(v) Describe the situation in which no work is done, although force is acting on the body and it is covering some displacement.

If an object is displaced by a force from its initial place but then back to the initial position again we can say there is no work being done by the object. Also, if a person starts walking from a certain point of a circular path and back to this particular point covering the circle. Then its work done is zero.

(vi) A car has kinetic energy 'K'. What will be effect on its kinetic energy if its velocity is doubled?

Kinetic energy K of a car is given by

$$K = \frac{1}{2}mv^2$$
$$K' = ?, \qquad v' = 2v$$
$$K' = \frac{1}{2}mv'^2$$
$$K' = \frac{1}{2}m(2v)^2$$
$$K' = \frac{1}{2}m4v^2$$
$$K' = 4\left(\frac{1}{2}mv^2\right)$$
$$K' = 4K$$

Hence, if the velocity of the car doubled then its kinetic energy increase by four times of the original kinetic energy.

(vii) Why is potential energy stored in the body when it is lifted to some height from surface of earth?

As we know that

$$P.E = mgh$$

It shows that potential energy depends upon mass, gravitational acceleration and height at which object is placed. As gravitational acceleration changes with altitude, so the potential energy will definitely changes with height. Hence potential energy is stored in the body when it is lifted some height from the surface.

(viii) Work done on the body either speed it up or slows it down or raises it up. Keeping it in mind, tell how much work is done by centripetal force on the orbiting satellite?

When object is moving in a circle due to centripetal force then at every point the direction of the body is at tangent to the centripetal force. Its mean at any instance the direction of force is perpendicular ($\theta = 90$) to the distance of the body. So the work done by satellite moving in an orbit is zero.

$$W = Fdcos\theta = Fdcos90 = Fd(0) = 0$$

(ix) A bullet is fired from gun, bullet penetrates into a sand wall and it stops. Where is its kinetic energy used?

A bullet is fired from the gun, bullet penetrates into a sand wall and it stops. Its kinetic energy is used in following ways.

- Sound energy
- Heat energy
- Deforming the bullet
- Deforming the target

(x) An energy saver bulb has efficiency of 80%. What does it mean?

As we know that efficiency is the ratio between input and output of a machine.

It means that the machine converts 80% of the power of its input fuel source to actual work. There is 20% waste likely as heat, noise or wear.

(xi) Tides can be used to generate electrical energy. Discuss a method to convert tidal energy into electrical energy?

Tidal energy can be used to generate electrical energy. During high tide, when the level of water in the sea is high, sea-water flows into the reservoir of the barrage and turns the turbines. The turbines then turn the generator to produce the electricity. And during the low tide, when the level of sea-water is low, the sea-water stored in the barrage reservoir is allowed to flow out into the sea. This flowing water also turns the turbines and generates electricity.

NUMERICAL PROBLEMS

Q. Solve the following numerical questions.

1. Calculate the work done in pushing a box with 150N through distance of 5m?

Data:

$$W = ?$$

$F = 150N$
$d = 5m$

Solution:

$W = Fd$
$W = (150)(5)$
$W = 750J$

2. A little boy is pulling his toy trolley by applying force of 20N at angle of $60°$ with ground and trolley moves through 5m. What is the work done by the boy.

Data:

$F = 20N$
$\theta = 60°$
$d = 5m$
$W = ?$

Solution:

$W = Fd\cos\theta$
$W = (20)(5)\cos 60$
$W = 100 \times 0.5$
$W = 50J$

3. In which case more work is done

a. A block of 100N is lifted straight up to height of 4m.

Data:

$w = F = 100N$
$h = d = 4m$
$W = ?$

Solution:

$W = Fd$
$W = (100)(4)$
$W = 400J$

b. 50N force is required to move the same block to same height with the help inclined plane of length 5m.

Data:

$F = 50N$
$d = 5m$
$W = ?$

Solution:

$W = Fd$
$W = (50)(5)$
$W = 250J$

4. A mason of 600N weight is climbing on a 12m high ladder. Find his P.E at the middle of ladder.

Data:

$W = 600N$
$h = \frac{12}{2} = 6m$
$P.E = ?$

Solution:

$P.E = mgh$
$P.E = Wh$
$P.E = (600)(6)$
$P.E = 3600J$

5. A boy weighing 75N jumps up and gains 300J of P.E. What height did the boy reach?

Data:

$w = 75N$

$P.E = 300J$
$h = ?$

Solution:

$P.E = mgh$
$P.E = Wh$
$h = \frac{P.E}{W}$
$h = \frac{300}{75}$
$h = 4m$

6. **A 5kg steel ball is at the top of a tower of height 12m. It is dropped. What is kinetic energy of the ball on hitting the ground? With what velocity, it will hit the ground? (Neglect the air resistance)**

Data:

$m = 5kg$
$h = 12m$
$K.E = ?$
$v = ?$

Solution:

$Gain\ in\ K.E = Loss\ in\ P.E$
$K.E = mgh$
$K.E = (5)(9.8)(12)$
$K.E = 588J$
$K.E = \frac{1}{2}mv^2$
$\frac{2K.E}{m} = v^2$
$v = \sqrt{\frac{2K.E}{m}}$
$v = \sqrt{\frac{2(588)}{5}}$
$v = \sqrt{235.2}$
$v = 15.3ms^{-1}$

7. **A 2hp electric motor gives energy to a pulley system that lifts a load of 10kg to height of 10m in 1.5s. Calculate**
   a. Input (work done by motor on pulley system) **b. Output (load lifted)**
   c. Efficiency of pulley system

Data:

$P = 2hp = 2(746W) = 1492W$
$m = 10kg$
$h = 10m$
$t = 1.5s$

a. $W = ?$
b. $P.E = ?$
c. $\eta = ?$

Solution:

a. $P = \frac{W}{t}$
$W = Pt$
$W = (1492)(1.5)$
$W = 2238J$

b. $P.E = mgh$
$P.E = (10)(10)(10)$
$P.E = 1000J$

c. $\eta = \frac{output}{input} \times 100\%$

$\eta = \frac{1000}{2238} \times 100\%$

$\eta = 44.6\%$

$\eta = 45\%$

8. A man weighing 60kg climbs upstairs with 20kg weight on his head. The stair case has 20 steps, each being 15cm high. If he takes 10 seconds to climb, find his power in watts and in horse power?

Data:

$m_1 = 60kg$

$m_2 = 20kg$

$M = m_1 + m_2$

$M = 60 + 20 = 80kg$

$n = 20steps$

$h' = 15cm = 0.15m$

$h = nh' = (20)(0.15) = 3m$

$t = 10s$

$P = ?$

Solution:

$P = \frac{W}{t}$

$P = \frac{Mgh}{t}$

$P = \frac{(80)(9.8)(3)}{10}$

$P = 235.2W$

$P = \frac{235.2}{746} hp$

$P = 0.32hp$

Chapter#7

PROPERTIES OF MATTER

MULTIPLE CHOICE QUESTIONS

1. Choose the best possible option.

(i) How many phases of matter are there?

(a) 1 (b) 2 (c) 3 ✓ (d) 4

(ii) In which of the materials, particles have only vibrational motion?

(a) solid ✓ (b) liquids (c) gas (d) no such matter exists

(iii) SI unit of pressure is:

(a) pascal ✓ (b) newton

(c) newton per metre (d) pascal & newton per metre

(iv) Which will exert greater pressure?

(a) 3g needle of tip area $1mm^2$

(b) 4000kg elephant of total feet area $0.5m^2$

(c) a girl of mass 40kg wearing high heel shoes of cross-sectional area $0.5cm^2$ ✓

(d) a loaded ship of mass $2.2 \times 10^7 kg$ having area $600m^2$

(v) Pressure of liquid in a container increases with:
(a) base (b) volume (c) depth ✓ (d) mass

(vi) Pressure is a
(a) scalar quantity ✓ (b) vector quantity (c) fixed quantity (d) base quantity

(vii) A stone in air weighs 20N. Its weight measured again when immersed in a liquid in 12N. The buoyant force acting on it is:
(a) 20N (b) 32N (c) 8N ✓ (d) 12N

(viii) Ice floats on water surface because
(a) its density greater than water (b) its density is smaller than water ✓
(c) it displaces more water when placed in water (d) none of them

(ix) Atmospheric pressure is measured by:
(a) hygrometer (b) barometer ✓ (c) manometer (d) thermometer

(x) A mass of 2kg is hung by spring which displaces it through 5cm. What is its spring constant?
(a) 392N/m ✓ (b) 40N/m (c) 4N/m (d) 4000N/m

(xi) Young's modulus has the same unit as that of:
(a) force (b) strain (c) pressure ✓ (d) no unit

(xii) Which will experience greater buoyant force?
(a) 1kg of helium filled balloon ✓ (b) 1kg of wood
(c) 1kg of iron (d) all experience same

(xiii) The volume of a submerged object is equal to the _____ of liquid displaced.
(a) weight ✓ (b) buoyancy (c) volume (d) mass

CONCEPTUAL QUESTIONS

2. Give a short response to the following questions

(i) A girl is walking on a carpet wearing high heel shoes, it leaves deep impressions on the carpet. Why?

A girl is walking on a carpet wearing high heel shoes, it leaves deep impressions on the carpet because her weight shifts greatly on the smaller area of her heels.

The Pressure is given by,

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

Therefore large pressure acting on her heels damages the carpet. Due to this pressure the pointed heels penetrate the carpeting and padding underneath.

(ii) Why dams are made thick at its bottom?

Dam is a barrier constructed to hold back water and rais its level.

As we know that the pressure P exerted by liquids increases with depth h.

$$P = \rho g h$$

So, as the depth increases, more pressure is applied at the bottom of the walls. That is why walls of the dam are made thicker at the bottom, so that they can handle high pressure exerted by water.

(iii) How does a sharp knife cut vegetables easily?

Pressure is given by

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

This shows that pressure is inversely proportional to the area in contact of the surface. A sharp knife has a smaller area that comes in contact with the object and hence more pressure can be applied on the object. Hence the sharp knife cut vegetables easily.

(iv) An inflated balloon is placed in a large glass jar. What will happen to the volume of balloon if we start evacuating the glass jar?

When an inflated balloon is placed inside a jar, the air pressure inside the balloon is equal to the air pressure on its outer side (i.e. air pressure in the jar)

If the jar is evacuated gradually the air pressure in the jar reduces and the inner pressure on the balloon becomes larger than its outer pressure. Hence the balloon starts to expand more and if it is already filled to the capacity it will burst.

(v) Why the reading on barometer decreases when we travel to higher altitude areas?

As altitude increases, density of the amount of gas molecules in the air decreases—the air becomes less dense and lighter than air nearer to sea level. This is what meteorologists and mountaineers mean by "thin air." Thin air exerts less pressure than air at a lower altitude. Hence the reading on barometer decreases when we travel to higher altitude areas.

(vi) If a liquid has density three times the density of mercury, what will be the height of the liquid column in barometer?

$\rho_{mercury} = 13.6kgm^{-3}$

$\rho_{liquid} = 3(13.6) = 40.8kgm^{-3}$

$h_{mercury} = 76cm = 0.76m$

$h_{liquid} = ?$

$P_{liquid} = P_{mercury}$

$\rho_{liquid} g h_{liquid} = \rho_{mercury} g h_{mercury}$

$\rho_{liquid} h_{liquid} = \rho_{mercury} h_{mercury}$

$(40.8)h_{liquid} = (13.6)(0.76)$

$$h_{liquid} = \frac{(13.6)(0.76)}{40.8}$$

$h_{liquid} = 0.253m$

(vii) How do we sip water from glass using straw? Can we sip water with straw on moon?

When we sip a liquid through the straw, we decrease the air pressure in the straw by removing the air from it. The pressure inside the straw then becomes lower than the atmospheric pressure. Due to this pressure difference, the atmospheric pressure pushes the liquid up the straw.

We cannot sip water with straw on moon because there is no air on the moon and therefore, no air pressure to push the liquid up the straw.

(viii) How can a submarine sink and float in sea?

A submarine can be made to float or sink in the water. This is controlled by ballast tanks.

When the tanks are empty, the overall density of the submarine is less, and the weight of the water displaced by the submarine is greater than the weight of the submarine. Hence it floats on water.

The submarine can be made to sink in water if the water is allowed to enter the tanks such that the overall density of the submarine increases and the weight of the submarine is greater than the weight of water displaced by it. Hence it sinks.

(ix) How can a fork lifter lift cars heavier than itself?

Fork lifter can lift heavier cars by applying following principles:

a. Hydraulic system based on Pascal's law: Fork lifter have electrical air pump at the base which draws outside air into the hydraulic cylinders. The cylinder allows gases to enter it without leaking them out. The volume of gas inside the cylinder raises the pressure inside it. This pressure is applied to the area of piston head generate upward force. This force causes the piston to move up and the load is lifted.

b. Principle of moment: A fork lifter works on the principle of moment (see-saw). There is a pivot point and a counter weight at one end to offset the load to be lifted. Too high weight causes it tip over.

NUMERICAL PROBLEMS

Q. Solve the following numerical questions.

1. **Density of iron is $7900kgm^{-3}$. Find the mass of a solid cube of iron if its side length is 15cm?**

Data:

$\rho = 7900kgm^{-3}$
$m = ?$
$l = 15cm = 0.15m$

Solution:

$\rho = \frac{m}{V}$
$\rho = \frac{m}{l \times w \times h}$
$m = \rho \times l \times w \times h$
$m = 7900 \times 0.15 \times 0.15 \times 0.15$
$m = 26.7kg$

2. **A $50cm \times 20cm \times 40cm$ metal box has mass of 2500g.**
   a. Find the density of the metal.
   b. Calculate the maximum pressure that this box can exert on table.

Data:

$V = 50cm \times 20cm \times 40cm = 40000cm^3 = 40000 \times 10^{-6}m^3 = 0.04m^3$
$m = 2500g = 2.5kg$
$\rho = ?$
$P = ?$

Solution:

$\rho = \frac{m}{V}$
$\rho = \frac{2.5}{0.04}$
$\rho = 62.5kgm^{-3}$
$P = \rho hg$
$P = (62.5)(0.5)(10)$
$P = 312.5Pa$

3. **Water column in a beaker is 70cm. Find the pressure of water in beaker (Density of water = $1000kgm^{-3}$)**

Data:

$h = 70cm = 0.7m$
$P = ?$
$\rho = 1000kgm^{-3}$

Solution:

$P = \rho hg$
$P = (1000)(0.7)(10)$
$P = 7000Pa$
$P = 7 \times 10^3 Pa$

4. **In a force multiplier, small piston has diameter of 15cm and large piston has diameter of 30cm. if 250N force is applied on the small piston then how much force will be produced on the large piston?**

Data:

$D_1 = 15cm = 0.15m$
$D_2 = 30cm = 0.30m$
$F_1 = 250N$
$F_2 = ?$

Solution:

$\frac{F_2}{A_2} = \frac{F_1}{A_1}$
$F_2 = F_1 \frac{A_2}{A_1}$
$F_2 = F_1 \frac{\pi r_2^2}{\pi r_1^2}$

$$F_2 = F_1 \frac{\pi\left(\frac{D_2}{2}\right)^2}{\pi\left(\frac{D_1}{2}\right)^2} = F_1 \frac{\pi D_2^2/4}{\pi D_1^2/4}$$

$$F_2 = F_1 \frac{D_2^2}{D_1^2}$$

$$F_2 = (250)\frac{(0.30)^2}{(0.15)^2}$$

$$F_2 = \frac{22.5}{0.0225}$$

$$F_2 = 1000N$$

5. **An iron piece in air has weight 26.6N. It is immersed in water, its weight in water is 12.8N. Find the volume of the iron piece? (Density of water = $1000kgm^{-3}$)**

Data:

$$W_{air} = 26.6N$$
$$W_{water} = 12.8N$$
$$V = ?$$
$$\rho = 1000kgm^{-3}$$

Solution:

$$F_B = W_{air} - W_{water}$$
$$mg = 26.6 - 12.8$$
$$mg = 13.8$$
$$m = \frac{13.8}{g}$$
$$m = \frac{13.8}{9.8}$$
$$m = 1.4kg$$
$$\rho = \frac{m}{V}$$
$$V = \frac{m}{\rho}$$
$$V = \frac{1.4}{1000}$$
$$V = 14 \times 10^{-4}m^3$$

6. **If 2.5m steel wire of cross-sectional area $10cm^2$ is stretched. Its length increases by $3mm$. If young's modulus of steel is $2 \times 10^{11}Nm^{-2}$. Find the value of the force applied on the steel wire.**

Data:

$$l = 2.5m$$
$$A = 10cm^2 = 10 \times 10^{-4}$$
$$\Delta l = 3mm = 3 \times 10^{-3}m$$
$$Y = 2 \times 10^{11}Nm^{-2}$$
$$F = ?$$

Solution:

$$Y = \frac{Fl}{A\Delta l}$$
$$\frac{YA\Delta l}{l} = F$$
$$F = \frac{YA\Delta l}{l}$$
$$F = \frac{(2\times10^{11})(10\times10^{-4})(3\times10^{-3})}{2.5}$$
$$F = \frac{600000}{2.5}$$
$$F = 240000N$$
$$F = 2.4 \times 10^5N$$

7. **A hydraulic car lift lifts a car of mass $1000kg$ when we apply force of 50N on the small piston. Radius of its small piston is 20cm. Find the radius of its large piston.**

Data:

$m_1 = 1000kg$
$F_2 = 50N$
$r_2 = 20cm = 0.2m$
$r_1 = ?$

Solution:

$F_1 = W_1 = m_1 g$
$F_1 = (1000)(10)$
$F_1 = 10000N$
$\frac{F_1}{A_1} = \frac{F_2}{A_2}$
$\frac{F_1}{\pi r_1^2} = \frac{F_2}{\pi r_2^2}$
$\frac{F_1}{r_1^2} = \frac{F_2}{r_2^2}$
$F_2 r_1^2 = F_1 r_2^2$
$r_1^2 = \frac{F_1 r_2^2}{F_2}$
$r_1^2 = \frac{(10000)(0.2)^2}{50}$
$r_1^2 = \frac{400}{50}$
$r_1^2 = 8$
$r_1 = 2.82m$

Chapter#8

THERMAL PROPERTIES OF MATTER

MULTIPLE CHOICE QUESTIONS

1. Choose the best possible option.

(i) Temperature is equal to _____ of substance.
(a) Average K.E of molecules ✓ (b) Individual K.E of each molecule
(c) Average P.E of molecules (d) Individual of P.E of each molecule

(ii) Boiling point of water is
(a) 212°C (b) 212°F ✓ (c) 100K (d) 373°C

(iii) J/kg K is unit of:
(a) Specific heat capacity ✓ (b) Heat capacity
(c) Latent heat of fusion (d) Heat energy

(iv) At which temperature, water has maximum density?
(a) 0°C (b) −4°C (c) −273K (d) 4°C ✓

(v) Evaporation takes place from _____ of liquid.
(a) Surface ✓ (b) Bottom (c) center (d) any location

(vi) Number of divisions on Fahrenheit scale between its reference points are:
(a) 100 (b) 173 (c) 212 (d) 180 ✓

(vii) By adding heat at melting point, the temperature of substance does not change. Heat added to substance is used to _____ of substance.

(a) Increase K.E of particles (b) Decrease K.E of particles ✓
(c) Increase the attraction between particles (d) Decrease the attraction between particles

(viii) 336J/g is latent heat of fusion of a material. How much heat is required to melt 10g of material at its melting point?
(a) 336J (b) 3360J ✓ (c) 33600J (d) 3.36x105J

(ix) Substances with their specific heats are given below. Which of the following substance will cool down quickly if heated for same temperature?
(a) Water (4200K/kg K) (b) Wood (1700J/kg K) (c) Copper (400J/kg K (d) Silver (250J/kg K) ✓

(x) On which of the following physical quantities, specific heat capacity of a substance depends:
(a) Mass (b) Temperature
(c) Nature (d) Mass & Temperature ✓

(xi) Water is used in radiators of automobiles as a coolant. Why?
(a) It is easily available (b) It is low cost or free
(c) It has large specific heat ✓ (d) all of these

(xii) At which value, temperature on Fahrenheit and Celsius scales have same readings?
(a) $0°$ (b) $-40°$ ✓ (c) $153°$ (d) $-32°$

(xiii) $10°C =$ _____ K:
(a) -263 (b) 273 (c) -283 (d) 283 ✓

CONCEPTUAL QUESTIONS

2. Give a short response to the following questions

(i) Why mercury is preferred over water as a thermometric substance?

Mercury is commonly used as a thermometric fluid rather than water because

I. Mercury has greater visibility than water.
II. Mercury has high melting and boiling points making it a liquid over a broad range of temperature.
III. Since it is a metal, it has a stable coefficient of expansion hence it expands uniformly and noticeably for a slight change of temperature.
IV. Mercury is a non-sticky viscous metal and hence it makes a clear meniscus, helpful in readings.

(ii) Water has large specific heat capacity. Give its practical application that uses this property?

Water is having the highest specific capacity and therefore, takes comparatively longer time to heat and cool down.

Water is used as coolant car radiators for its high specific heat capacity, due to which it can absorb a large amount of heat energy from the engine of the car, without its temperature rising too high.

(iii) Why does temperature of liquids not change when heated at their boiling point?

Temperature of liquids does not change when heated at their boiling point due to latent heat of vaporization. Once the boiling point is reached the heat supplied is used by the molecules of the liquid to overcome inter-molecular forces and escape as gas molecules from the surface of the liquid.

(iv) Why metallic handle of a door is colder than the wood of the same door when touched?

The body that has high thermal conductivity will conduct heat faster. As the metal has high thermal conductivity then the wood so metal will conduct heat faster. Hence, it takes away our body heat as we touch it and which makes our body temperature to drop, therefore we feel the coldness when we touch a piece of metal. Hence metallic conductor of a door is colder than the wood of the same door when touched.

(v) Which type of clothes do the people of desert wear and why?

People of desert wear clothing involves multiple layers of clothes and it usually covers most of the skin. Having multiple layers means that they are trapping air between the layers of clothes and that acts as an insulation that helps to keep the heat out. The layer closest to the body also helps keep sweat near the body and slows its evaporation which actually helps the natural cooling method to be more efficient.

(vi) Why does temperature of sea shore cities remain moderate during most of the year? Why does temperature of land areas vary more during winters and summers?

Water has about four times higher heat capacity than land, i.e. it takes much more energy to increase the water temperature.

It's difficult for the sun to heat up or cool down the sea due to large specific heat capacity of water. Since the sea doesn't get too hot or cold, the air above the sea also doesn't get too hot or cold. Therefore places near the sea usually have temperatures that remain fairly constant throughout the year. They have what is known as a moderate climate.

Land heats up and cools down soon due to small specific heat capacity. That's why the temperature of land areas vary more during winters and summers.

(vii) During the process of sweating (perspiration), we feel cooling during a hot day. Why?

We feel cooling during a hot day during the process of sweating. That's because cooling our body via sweating relies on a principle of physics called "heat of vaporization." It takes energy to evaporate sweat off of your skin, and that energy is heat. As your excess body heat is used to convert beads of sweat into vapor, you start to cool down.

(viii) How a bimetallic strip, made up of copper and iron is used as automatic switch in different devices? Give one example.

A bimetal strip consists of two thin strips of different metals such as brass and iron joined together. On heating the strip, brass expands more than iron. This unequal expansion causes bending of the strip. This expansion of bimetal strip act as automatic switch in different devices.

Bimetal strips are used for various purposes. Bimetal thermometers are used to measure temperatures especially in furnaces and ovens. Bimetal strips are also used in thermostats.

(ix) How is anomaly in the expansion of water help marine life to survive in extremely cold areas?

The anomalous expansion of water helps preserve aquatic life during very cold weather. When temperature falls, the top layer of water in a pond contracts, becomes denser and sinks to the bottom. A circulation is thus set up until the entire water in the pond reaches its maximum density at 4°C.

(x) Why rollers are used at the ends of steel bridges?

Rollers are used at the ends of steel bridges because bridges made of steel girders expand during the day and contract during night. They will bend if their ends are fixed. To allow thermal expansion, one end is fixed while the other end of the girder rests on rollers in the gap left for expansion.

NUMERICAL PROBLEMS

Q. Solve the following numerical questions.

1. **In Islamabad, temperature at night during winters falls to 0°C and temperature during a hot day in summer rises up to 40°C.**
   a. Convert these temperatures into Kelvin and Fahrenheit scales
   b. Find the temperature difference for each scale of these temperatures
   c. what relation you find in these temperature differences for Kelvin and Celsius scales & Celsius & Fahrenheit scales.

Data:

$T_{C1} = 0°C$
$T_{C2} = 40°C$

Solution:

(a) $T_{K1} = T_{C1} + 273 = 0 + 273 = 273K$
$T_{K2} = T_{C2} + 273 = 40 + 273 = 313K$
$T_{F1} = \frac{9}{5}T_{C1} + 32 = \frac{9}{5}(0) + 32 = 0 + 32 = 32°F$
$T_{F2} = \frac{9}{5}T_{C2} + 32 = \frac{9}{5}(40) + 32 = 72 + 32 = 104°F$

(b) $\Delta T_C = T_{C2} - T_{C1} = 40 - 0 = 40°C$
$\Delta T_K = T_{K2} - T_{K1} = 313 - 273 = 40K$
$\Delta T_F = T_{F2} - T_{F1} = 104 - 32 = 72F$

(c) $40\Delta T_C = 40\Delta T_K = 72\Delta T_F$
$\Delta T_C = \Delta T_K = 1.8\Delta T_F$

2. Consider a steel bar of length 1.5m at $10°C$. It is heated to raise temperature to $100°C$. Find
a. Increase in length **b. Final length at $100°C$**
(Coefficient of linear thermal expansion of steel is $1.2 \times 10^{-5}K^{-1}$)

Data:

$L_1 = 1.5m$
$T_1 = 10°C$
$T_2 = 100°C$
$\Delta L = ?$
$L_2 = ?$
$\alpha = 1.2 \times 10^{-5}K^{-1}$

Solution:

$\Delta T = T_2 - T_1$
$\Delta T = 100 - 10$
$\Delta T = 90°C$
$\Delta L = \alpha L_1 \Delta T$
$\Delta L = (1.2 \times 10^{-5})(1.5)(90)$
$\Delta L = 162 \times 10^{-5}m$
$\Delta L = 1.62 \times 10^{-3}m$
$\Delta L = 1.62mm$
$\Delta L = L_2 - L_1$
$L_2 = \Delta L + L_1$
$L_2 = 162 \times 10^{-5} + 1.51$
$L_2 = 1.50162m$

3. A solid cube of side length 10cm at $25°C$ is heated. What will be the increase in its volume at $125°C$ if its coefficient of linear thermal expansion is $9 \times 10^{-6}K^{-1}$.

Data:

$l = 10cm = 0.1m$
$V_1 = l^3 = (0.1)^3 = 0.001m^3$
$T_1 = 25°C$
$\Delta V = ?$
$T_2 = 125°C$
$\alpha = 9 \times 10^{-6}K^{-1}$

Solution:

$\Delta T = T_2 - T_1$
$\Delta T = 125 - 25$
$\Delta T = 100°C$
$\Delta V = \beta V_1 \Delta T$
$\Delta V = (3\alpha)V_1 \Delta T$
$\Delta V = (3 \times 9 \times 10^{-6})(0.001)(100)$
$\Delta V = (27 \times 10^{-6})(0.1)m^3$
$\Delta V = 2.7 \times 10^{-6}m^3$
$\Delta V = 2.7 \times (10^{-2})^3 m^3$
$\Delta V = 2.7cm^3$

4. Find amount of heat given to 25kg of water to increase its temperature by $50°C$.

Data:

$Q = ?$

$m = 25kg$
$\Delta T = 50°C$
$C = 4200\,Jkg^{-1}K^{-1}$

Solution:

$Q = mC\Delta T$
$Q = (25)(4200)(50)$
$Q = 5.25 \times 10^6 J$

5. How much heat is required to change 15kg of ice into water at its melting point.

Data:

$Q = ?$
$m = 15kg$
$L_f = 333000Jkg^{-1}$
$\Delta T = 100°C$

Solution:

$Q = mL_f$
$Q = (15)(333000)$
$Q = 4995000J$
$Q = 4.995 \times 10^6 J$

6. How much heat is required to change 7kg of water into steam at its boiling point.

Data:

$Q = ?$
$m = 7kg$
$H_f = 2260000Jkg^{-1}$

Solution:

$Q = mH_f$
$Q = (7)(2260000)$
$Q = 15820000J$
$Q = 1.582 \times 10^7 J$
$Q = 1.6 \times 10^7 J$

7. 4kg of ice has the temperature of $-20°C$. It is heated to convert into steam. Its final temperature is $120°C$. Calculate the total amount of heat energy involved for this conversion of ice into steam.

- **Specific heat of ice = 2100J/Kg K,**
- **Specific heat of water is 4200J/kg K,**
- **Specific heat of steam 2000 J/Kg K,**
- **Latent heat of fusion of ice = $3.3 \times 10^5 J/kg$**
- **Latent heat of vaporization of water = $3.3 \times 10^5 J/kg$**

Data:

$m = 4kg$
$T_1 = -20°C$
$T_2 = 120°C$
$Q = ?$

Heat required to convert the ice in to

$$\underset{ice}{-20°C} \rightarrow \underset{ice}{0°C} \rightarrow \underset{water}{0°C} \rightarrow \underset{water}{100°C} \rightarrow \underset{steam}{100°C} \rightarrow \underset{steam}{120°C}$$

Solution:

For $\underset{ice}{-20°C} \rightarrow \underset{ice}{0°C}$

$\Delta T = 0 - (-20) = 20°C$
$Q_1 = mc\Delta T$
$Q_1 = (4)(2100)(20)$
$Q_1 = 168000J$

For $\underset{ice}{^{0_oC}} \rightarrow \underset{water}{^{0_oC}}$

$Q_2 = Q_f = mH_f$

$Q_2 = (4)(3.3 \times 10^5)$

$Q_2 = 1320000J$

For $\underset{water}{^{0_oC}} \rightarrow \underset{water}{^{100_oC}}$

$\Delta T = 100 - 0 = 100°C$

$Q_3 = mc\Delta T$

$Q_3 = (4)(4200)(100)$

$Q_3 = 1680000J$

For $\underset{water}{^{100°C}} \rightarrow \underset{steam}{^{100°C}}$

$Q_4 = Q_f = mH_f$

$Q_4 = (4)(3.3 \times 10^5)$

$Q_4 = 1320000J$

For $\underset{steam}{^{100°C}} \rightarrow \underset{steam}{^{120°C}}$

$\Delta T = 120 - 100 = 20°C$

$Q_5 = mc\Delta T$

$Q_5 = (4)(2000)(20)$

$Q_5 = 160000J$

$Q = Q_1 + Q_2 + Q_3 + Q_4 + Q_5$

$Q = 168000 + 1320000 + 1680000 + 1320000 + 160000$

$Q = 4648000J$

$Q = 4.65 \times 10^6 J$

Chapter#9

TRANSFER OF HEAT

MULTIPLE CHOICE QUESTIONS

1. Choose the best possible option.

(i) A group of people enjoying bonfire is an example of heating by:

(a) Conduction (b) Conversion

(c) Radiation ✓ (d) Convection & radiation

(ii) Temperature of a metal spoon rises placed in hot water. This is due to:

(a) Conduction ✓ (b) Convection (c) Radiation (d) All of these

(iii) Unit of thermal conductivity is:

(a) $Jkg^{-1}K^{-1}$ (b) $Js^{-1}m^{-1}K^{-1}$ ✓ (c) $Wm^{-1}K$ (d) $Js^{-1}mK^{-1}$

(iv) Which of the following is the best conductor?

(a) Aluminium (b) Wood (c) Plastic (d) Copper ✓

(v) Which of the following is the best insulator?

(a) Wood (b) Plastic (c) Rubber (d) Air ✓

(vi) Dull black colour on a surface is the best absorber, which of the following is the best radiator?

(a) Dull black surface ✓ (b) Shining silver surface (c) Red coloured surface (d) White surface

(vii) Which of the following is a good reflector?
(a) Dull black surface (b) Shining silver surface ✓ (c) Red coloured surface (d) White surface

(viii) In which of the following methods heat is transferred due to actual movement of its particles?
(a) Conduction (b) Convection ✓
(c) Radiation (d) Convection & radiation

(ix) The transfer of heat that takes place because of density difference in fluids is:
(a) Conductors (b) Radiation (c) Convection ✓ (d) Insulation

(x) Thermal conductivity of ceiling of a room is K. If its thickness is doubled then value of its thermal conductivity becomes:
(a) K/2 (b) 2K ✓ (c) 4K (d) K

CONCEPTUAL QUESTIONS

2. Give a short response to the following questions

(i) How does heat transfer occurs through the windows and vents of a room?

Heat transfer by convection occurs through cold air entering the room around windows and hot air leaving the room by rising up the chimney.

When air is heated up in the lower levels near the floor, it expands and rises due to its lower density. At the same time, the cooler and denser air in the upper levels sinks. This creates a continuous air current (convectional current) that warms up the room from the bottom going up, gradually.

(ii) Why should we wear dark coloured clothes in winters and white coloured clothes in summer?

We prefer white clothes in summer because white clothes reflect most of the sun's heat and absorb very little of the sun's heat and keeps our body cool. We prefer to wear black or dark coloured clothes in winter as dark clothes absorb most of the sun's heat and keep our body warm.

(iii) Two shirts are warmer than single shirt of double thickness. Why?

Two shirts are warmer than a single shirt of double thickness because when someone wear two shirts a layer of air gets trapped between the two shirts. The air is a bad conductor of heat so this layer of air present between the two shirts behave like thermal insulation, hence trap the heat inside and keeps the body warm.

(iv) A piece of copper and glass are heated to same temperature, why does the copper feel hotter than glass on touching them?

A piece of copper and glass are heated to same temperature, the copper feel hotter than the glass on touching them. Copper is a good conductor of heat whereas glass is a bad conductor. So when copper is touched heat flows from copper to the hand quickly. But heat conduction from glass to human body is slow. So the piece of copper feels hotter.

(v) In a house, geysers or water boiler is fitted in ground floor and still we get warm water at top floor without using pump. How is it possible?

In a house, geysers or water boiler is fitted in ground floor and still we get warm water at top floor without using pump. By the process of convection hot water will rise up and cold water moves down to the geysers or water boiler which is fitted on ground floor. This process of convection continues until all the water get warm.

(vi) Where will you get more heat from the wood fire, 1 metre above the woods or 1 metre in front of woods?

We get heat above the wood fire by the process of convection and we get heat in front of wood fire by the process of radiation. As the atoms or molecules move and carry heat energy in the process of convection. So we get more energy 1 meter above the wood fire.

(vii) Why do birds fluff out during winters?

When the birds puff up their feathers they trap a large amount of air. We know that air is a bad conductor of heat. So, heat from the body of a bird does not flow out. Hence, the bird feels warm.

(viii) How does the gliders can fly very high without any engines?

A glider is a fixed-wing aircraft that is supported in flight by the dynamic reaction of the air against its lifting surfaces, and whose free flight does not depend on an engine.

Air near the ground expands and rises as the surface of the Earth is heated, producing thermal air currents. It helps the gliders to fly very high without any engine.

(ix) How do land breeze and sea breeze blow?

Land breeze: Land breeze occurs during the night time. This is because during the night time, land gets cooled faster than the sea and the warm air above the sea rises up. Thus the cold air from the land flows towards the sea causing land breeze.

Sea breeze: A sea breeze occurs during the day time. This is because during the day time, land gets warm faster than the sea and the air above it begins to rise. Thus the cold air from the sea flows towards the land causing sea breeze.

(x) Why are freezer compartments at the top of refrigerators?

Freezer is the source for the refrigerator's coldness. When the freezer is placed on top, the cold air produced from it is denser than the warmer air in the bottom. So cold air being dense sinks down and the warm air is forced to rise up so when the warm air rises up it and gets cold in the freezer.

NUMERICAL PROBLEMS

Q. Solve the following numerical questions.

1. **During winter, heat escapes from your home through the glass windows that open to the lawn. What is the rate of the flow of heat through a window of thickness $10cm$ an area $2m^2$ if temperature in the room is $15℃$ and that of laws is $-1℃$. (Thermal conductivity of glass is $0.8Wm^{-1}K^{-1}$)**

Data:

$Rate\ of\ flow\ of\ heat = \frac{Q}{t} = ?$

$L = 10cm = 0.1m$

$A = 2m^2$

$T_1 = 15℃ = 15 + 273 = 288K$

$T_2 = -1℃ = -1 + 273 = 272K$

$K = 0.8Wm^{-1}K^{-1}$

Solution:

$$Rate\ of\ flow\ of\ heat = \frac{Q}{t} = \frac{KA(T_1 - T_2)}{L}$$

$$Rate\ of\ flow\ of\ heat = \frac{(0.8)(2)(288 - 272)}{0.1}$$

$$Rate\ of\ flow\ of\ heat = \frac{(0.8)(2)(16)}{0.1}$$

$$Rate\ of\ flow\ of\ heat = \frac{25.6}{0.1}$$

$$Rate\ of\ flow\ of\ heat = 256Js^{-1}$$

2. **Calculate the amount of heat that flows through a copper rod ($K = 390Wm^{-1}K^{-1}$) of length half metre and cross-sectional area $5 \times 10^{-4}m^2$ in one minute, while temperature difference of $50℃$ is maintained between its ends.**

Data:

$Q = ?$

$K = 390Wm^{-1}K^{-1}$

$L = 0.5m$

$A = 5 \times 10^{-4}m^2$

$t = 1min = 60s$

$\Delta T = 50℃ = 50K$

Solution:

$$\frac{Q}{t} = \frac{KA(T_1 - T_2)}{L}$$

$$Q = \frac{KA(T_1 - T_2)t}{L}$$

$$Q = \frac{(390)(5 \times 10^{-4})(50)(60)}{0.5}$$

$$Q = \frac{585}{0.5}$$

$$Q = 1170J$$