Universal Notes Series

Universal Physics Notes

For 9th Class

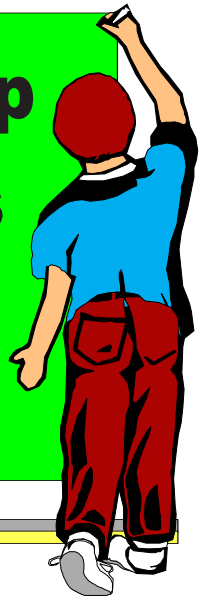
Contains :

Multiple Choice Questions with Help

Exercise Short Questions Answers

Impotant Formulas

Solution of Problems



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Knowledge is Power

There are no copy right of this book. Share these notes with maximum students ,teachers and schools .These notes are extract of three year experience .But a window for improvement is also open.After 1 year struggle and hard work I complete these notes . For any type of improvement in these notes ,comment on our facebook page , what's app number.

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Dedicated to: My students

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چند باتیں

کلاس روم میں سناٹا طاری تھا۔ طلبا کی نظریں کبھی پروفیسر کی طرف اٹھتیں اور کبھی بلیک بورڈ کی طرف۔ پروفیسر کے سوال کا جواب کسی کے پاس نہیں تھا۔ سوال تھا ہی ایسا۔

وزیٹنگ پروفیسر انصاری نے ہال میں داخل ہوتے ہی بغیر ایک لفظ کہے بلیک بورڈ پر ایک لمبی لکیر کھینچ دی۔ پھر اپنا رخ طلبا کی طرف کرتے ہوئے پوچھا

''تم میں سے کون ہے جو اس لکیر کو چھوئے بغیر اسے چھوٹا کر دے؟''

یہ ناممکن ہے۔''، کلاس کے ایک ذہین طالبعلم نے آخر کار اس خاموشی کو توڑتے ہوئے جواب دیا۔ لکیر کو چھوٹا کرنے کے لیے اسے مٹانا پڑے گا اور آپ اس لکیر کو چھونے سے بھی منع کر رہے ہیں۔ باقی طلبا نے بھی گردن ہلا کر اس کی تائید کر دی۔

پروفیسر نے گہری نظروں سے طلبا کو دیکھا اور کچھ کہے بغیر مسکراتے ہوئے بلیک بورڈ پر اس لکیر کے نیچے ہی اس سے بڑی ایک اور لکیر کھینچ دی۔ اب اوپر والی لکیر کے سامنے یہ لکیر چھوٹی نظر آ رہی تھی۔

:پروفیسر نے چاک ٹیبل پر رکھتے ہوئے کہا

آپ نے آج اپنی زندگی کا ایک بڑا سبق سیکھا ہے، وہ یہ ہے دوسروں کو نقصان پہنچائے بغیر، ان کو بدنام کیے بغیر، ان سے حسد کیے بغیر، ان سے الجھے بغیر ان سے آگے کس طرح نکلا جا سکتا ہے

آگے بڑھنے کی خواہش انسان کی فطرت میں شامل ہے۔ اس خواہش کی تکمیل کا ایک طریقہ یہ ہے کہ دوسرے کو چھوٹا بنانے کی کوشش کی جائے۔ مگر ایسی صورت میں انسان خود بڑا نہیں ہوتا۔ دوسرا طریقہ یہ ہے کہ دوسروں سے الجھے بغیر خود کو طاقتور اور بڑا بنانے پر توجہ دی جائے۔ دوسروں سے الجھے بغیر آگے بڑھنا، ترقی کا صحیح طریقہ ہے۔ یہ طریقہ فرد کے لیے بھی بہتر ہے اور قوموں کے لیے بھی۔

خیر اندیش

انجینئر محمد رضوان

Physical Quantities and Measurement

Q.1.1 Encircle the correct answer from the given choices.

i. The number of base units in SI are :
(a) 3 (b) 6 (c) 7 (d) 9

ii. Which one of the following unit is not derived unit?
(a) pascal (b) kilogramme (c) newton (d) watt

iii. Amount of a substance in term of numbers is measured in :
(a) gram (b) kilogramme (c) newton (d) mole

iv. An interval of 200μs is equivalent to :
(a) 0.2 s (b) 0.02 s (c) 2×10^{-4}s (d) 2×10^{-6}s

Explanation:

$200\mu s = 200 \times 10^{-6}$ $(\therefore 1\mu = 10^{-6})$

$200\mu s = 2 \times 10^{2} \times 10^{-6}$

$200\mu s = 2\times 10^{2-6}$

$200\mu s = 2\times 10^{-4}$

v. Which one of the following is the smallest quantity?
(a) 0.01g (b) 2mg (c) 100μg (d) 5000ng

vi. Which instrument is most suitable to measure the internal diameter of a test tube?
(a) metre rule (b) vernier calipers
(b) measuring tap (d) screw gauge

Explanation:

Screw gauge is used for measuring internal diameter. Vernier calipers are used for measuring internal and external diameter.

vii. A student claims the diameter of a wire as 1.032 cm using vernier callipers. Upto what extent do you agree with it?

(a) 1 cm (b) 1.0 cm (c) 1.03 cm (d) 1.032 cm

Explanation:

Least count of vernier caliper is 0.01 cm. In cm LC has 2 decimal places. So diameter of a wire should be upto two decimal places. So 1.03 cm is correct.

viii. A measuring cylinder is used to measure:

(a) mass (b) area (c) volume (d) level of a liquid

ix. A student noted the thickness of a glass sheet using a screw gauge .On the main scale, it reads 3 division while 8^{th} division on the circular scale coincides with index line. Its thickness is :

(a) 3.8 cm (b) 3.08 mm (c) 3.8 mm (d) 3.08 m

Explanation:

Circular scale division coinciding with the index line=8^{th}

Main scale reading = 3 mm

Circular scale reading = 8 × LC

= 8× 0.01 mm

= 0.08 mm

Thickness of glass sheet = Main scale reading

+ Circular scale reading

= 3 mm + 0.08 mm

Thickness of glass sheet = 3.08 mm

x. Significant figures in an expression are :

(a) all the digit
(b) all the accurately known digit
(c) all the accurately known digit and the first doubtful digit
(d) all the accurately known and all the doubtful digits

Ans:

i. c ii. b iii. d iv. C v. d vi. b vii. c viii. c ix. b x. c

Exercise Short Questions

Q.1 what is the difference between base quantities and derived quantities? Give three examples in each case.

Ans.

Sr.#	Base Quantities	Derived Quantities
	Base quantities are the quantities on the basis of which other quantities are expressed	The quantities that are expressed in terms of base quantities are called derived quantity.
	There are seven base quantities.	Numbers of derived quantities are greater than seven.
	Base Quantities are length, mass and time etc.	Derived quantities are speed, velocity and force etc.

Q.1.3 Pick out the base units in the following: joule, newton, kilogramme, hertz, mole, ampere, metre, kelvin, coulomb and coulomb and watt.

Ans. Kilogramme, mole, ampere, metre and kelvin are base units.

Q.1.4 Pick out the base quantities involved in each of the following derived quantities:

(a) speed (b) volume (c) force (d) work

Ans. Speed: It is a distance covered per unit time i.e.

$$\text{Speed} = \frac{\text{distance covered}}{\text{time taken}}$$

$$v = \frac{S}{t}$$

So in speed base quantities involved are length (distance) and time.

Force: As we know that

$$F = m\,a$$

$$F = m \times \frac{\Delta v}{t}$$

$$F = m \times \frac{d/t}{t}$$

$$F = \frac{md}{t^2}$$

So base quantities involved in force are mass, length and time.

Work: As we know that

Work = force × displacement

$$W = FS$$

$$W = ma\ S \qquad \therefore F = ma$$

$$W = m\frac{\Delta v}{t}\ S \qquad \because a = \frac{\Delta v}{t}$$

$$W = m\frac{d/t}{t}\ S$$

$$W = \frac{mdS}{t^2}$$

So base quantities involved in work are mass, length and time.

Q.1.5 Estimate your age in seconds.

Ans. My age in years = 14 years

My age in months =14 × 12 months

My age in months =168 months

My age in days =168× 30 days

My age in days = 5040 days

My age in hours =5040 × 24 hours

My age in minutes =120960 hours

My age in minutes =120960× 60 minutes

My age in minutes = 7257600 minutes

My age in seconds =7257600×60 seconds

My age in seconds =435456000 seconds

Q.1.6.What role SI units have played in the development of science?

Ans. SI units have played very important role in the development of science and technology. With the development in the field of science technology, the need for a commonly acceptable system of units was seriously felt all over the world, particularly to exchange scientific and technical information. This need was fulfilled by SI units. SI units have made easier to share technical and scientific information all over the world.

Q.1.7. What is meant by vernier constant?

Ans. The difference between one small division on main scale division and one vernier scale division is 0.1 mm. It is called least count of vernier calipers. It is also known as vernier constant.

Q.1.8. What do you understand by the zero error of a measuring instrument?

Ans. Any error in the measuring instrument is called its zero error. It is a defect in a measuring instrument.

Q.1.9 Why is the use of zero error necessary in a measuring instrument?

Ans. The zero error helps in correcting the misreading we get from any instrument. By knowing the zero error, necessary correction can be made to find the correct measurement.

Q.1.10 What is stopwatch? What is the least count of a mechanical stopwatch you have used in the laboratories?

Ans. A stopwatch can be used to measure time interval of an event. Least count of mechanical stopwatch which is used in laboratories is 0.1second.

Q.1.11 Why do you need to measure extremely small interval of times?

Ans. We need to measure extremely small interval of times for obtaining greater accuracy in the result.

Q. 1.11 What is meant by significant figures in a measured quantity?

Ans. The measured observation is expressed in digits. The significant figures are all the digits that are accurately and the one estimated.

More significant figure means greater precision.

Q.1.13 how is precision related to the significant figures in the measured quantity?

Ans. Precision means how close the measured values to each other. More significant figure means greater precision. Thus, a measured quantity having more significant figures will be more precise.

Important Formula, units and values for Problems

Least count of the screw gauge = $\frac{\text{pitch of the screw gauge}}{\text{no. of divisions on circular scale}}$

Positive zero error = vernier scale div. coinciding with main scale × LC

Zero correction = -zero error

Area of rectangle = length × width

SI unit for Area is m^2

1 mega (M) = 10^6 1 killo (k) = 10^3 1 milli (m) = 10^{-3}

1 micro (μ) = 10^{-6} 1 nano(n) = 10^{-3} 1 pico (p)= 10^{-12}

Least count of vernier callipers = 0.1 mm or 0.01 cm

Least count of screw gauge = 0.01 mm or 0.001 cm

Problems

1.1 Express the following quantities using prefixes.

(a) 500 g
(b) 2000 000 W
(c) 52× 10^{-10} kg
(d) 225× 10^{-8} s

Solution:

(a) 5000g

= 5 ×10^3g

= 5kg (∵ k = 10^3)

(b) 2,000,000 W

= 2 ×10^6 W

= 2 MW ($\because$ M = 10^6)

(c) 52 ×10^{-10}Kg

= 52 × 10^{-10} × 10^3g ($\because$ k= 10^3)

= 52 ×10^{-10+3}g

= 52 ×10^{-7}g

= 5.2 ×10^1×10^{-7}g

= 5.2 × 10^{1-7}g

= 5.2 ×10^{-6}g

= 5.2 µg ($\because$ µ = 10^{-6})

(d) 225 ×10^{-8}s

= 2.25 ×10^2 × 10^{-8}s

= 2.25 ×10^{2-8}s

= 2.25 ×10^{-6}s

= 2.25 µs ($\because$ µ= 10^{-6})

1.2 How do the prefixes micro, nano and pico relate to each other?

We know that,

One micro = 1µ = 10

One micro = 1n = 10^{-9}

One pico = 1p =10^{-12}

1µ = 10^{-6} ×10^{-3} × 10^3

1µ =10^{-6-3} ×1000

1µ =1000 × 10^{-9}

1µ =1000n ($\because$ n= 10^{-9})

1n = 10^{-9}

1n = 10^{-9} ×10^{-3} × 10^3

1n = 10^{-9-3} × 10^3

1n = 10^{-12} ×1000

$1n = 1000 \times 10^{-12}$

$1n = 1000p$ $(\because 1p = 10^{-12})$

1.3 Your hairs grow at the rate of 1mm per day. Find their growth rate in nms^{-1}.

Given date:

Hairs Growth rate = 1 mm per day

Required:

Hairs Growth rate in nms^{-1}=?

Solution:

Hairs Growth rate = 1 mm per day

$$= \frac{1mm}{day}$$

$$= \frac{1\times10^{-3}}{1\times24\times60\times60} ms^{-1}$$

$$= \frac{1\times10^{-3}}{86400} ms^{-1}$$

$$= \frac{1\times10^{-3}\times10^{-6}\times10^{6}}{86400} ms^{-1}$$

$$= \frac{1\times10^{-9}\times10^{6}}{86400} ms^{-1}$$

$$= \frac{1\times1000000\times10^{-9}}{86400} ms^{-1}$$

$$= \frac{1000000}{86400}\times10^{-9} ms^{-1}$$

Hairs Growth rate in nms^{-1} $= 11.57\ nms^{-1}$ $(\therefore 10^{-9} = n)$

1.4 Rewrite the following in standard form

(a) 1168×10^{-27}

(b) 32×10^{-5}

(c) 725×10^{-5}

(d) 0.02×10^{-8}

Solution:

(a) 1168×10^{-27}

$1168\times10^{-27} = 1.168\times10^{3}\times10^{-27}$

$1168\times10^{-27} = 1.168\times10^{3-27}$

$1168\times10^{-27} = 1.168\times10^{-24}$

(b) 32×10^{5}

$35\times10^{5} = 3.2\times10^{1}\times10^{5}$

$32\times10^{5} = 3.2\times10^{1+5}$

$32\times10^{5} = 3.2\times10^{6}$

(c) 725×10^{-5} Kg

725×10^{-5} kg $= 725\times10^{-5}\times10^{3}$ kg ($\because k = 10^{3}$)

$= 7.25\times10^{2}\times10^{-5}\times10^{3}$kg

$= 7.25\times10^{2-5+3}$ g

$= 7.25\times10^{5-5}$g

$= 7.25\times10^{0}$g ($\because 10^{0} = 1$)

725×10^{-5} Kg = 7.25g

(d) 0.02×10^{-8}

$0.02\times10^{-8} = 2\times10^{-2}\times10^{-8}$

$= 2\times10^{-2-8}$

$0.02\times10^{-8} = 2\times10^{-10}$

1.5 Write the following quantities in standard form.

(a) 6400 km

(b) 380 000 km

(c) 300 000 000 ms^{-1}

(d) second in a day

(a) 6400 Km

$= 6.4\times10^{3}$ Km

(b) 380000 Km

$= 38 \times 104$ Km

$= 3.8 \times 10^{1} \times 10^{4}$Km

$= 3.8 \times 10^{1+4}$ Km

$= 3.8 \times 10^{5}$ Km

(d) Seconds in a day = $1 \times 24 \times 60 \times 60$ s

$= 86400$s

$= 864 \times 10^{4}$s

$= 8.64 \times 10^{2} \times 10^{2}$s

$= 8.64 \times 10^{2+2}$s

Seconds in a day = 8.64×10^{4}s

1.6 On closing the jaws of a vernier calipers, zero of the vernier scale is on the right to its main scale such that 4th division of its vernier scale coincides with one of the main scale division. Find its zero error and zero correction.

Given that:

Vernier scale diversion coinciding With main scale = 4^{th} div

Required:

Zero errors =?

Zero correction =?

Solution:

On closing the Jaws of a Vernier scale calipers, zero of the Vernier scale is on the right to its main scale. So, zero error is positive.

Zero error = + Vernier scale div coinciding with main scale × Least count

$= + 4 \times 0.01$cm

Zero error = + 0.04cm

Zero correction = - Zero error

Zero correction = - (+ 0.04)

Zero correction = - 0.04

1.7 A screw gauge has 50 divisions on its circular scale. The pitch of the screw gauge is 0.5mm.What is its least count.

Given data:

No. of divisions on circular scale = 50

Pitch of the screw gauge = 0.5mm

Required:

Least count of Screw gauge = LC =?

Solution:

We know that

$$\text{Least count} = \frac{\text{pitch of the screw gauge}}{\text{no. of divisions on circular scale}}$$

$$LC = \frac{0.5mm}{50}$$

$$LC = 0.01 \text{ mm}$$

$$LC = \frac{0.01}{10} \text{ cm}$$

$$LC = 0.001 \text{ cm}$$

1.8 Which of the following have three significant figures?

(a) 3.0066 m (b) 0.00309 kg

(c) 5.05×10^{-27}kg (d) 301.0 s

Solution: (c) has 3 significant figures.

1.9 What are the significant figures in the following measurements?

(a) 1.009 m (b) 0.00450 kg

(c) 1.66×10^{-27}kg (d) 2001 s

Solution:

(a) 1.009m has 4 significant figures.

(b) 0.00450 kg has 3 significant figures.

(c) 1.66×10^{-27} kg has 3 significant figures.

(d) 2001 s has 4 significant figures.

1.10 A chocolate wrapper is 6.7cm long and 5.4 cm wide. Calculate its area upto reasonable number of significant figures?

Given data:

Length of chocolate wrappers = l = 6.7 cm

Width of chocolate wrapper = W = 5.4cm

Required:

Area up to reasonable significant figure = A =?

Solution:

We know that

$A = l \times w$

$A = 6.7 \times 5.4$ cm

$A = 36.18 cm^2$

In case of multiplication of numbers, the numbers of significant figures of the product should of equal to the number of significant figures of number having least significant has two significant figures. So, we round 36.18 cm^2 up to two significant figures.

Area up to reasonable significant figures = 36 cm^2

Q.2.1 Encircle the correct answer from the given choices:

i. A body has translatory motion if it moves along a

(a) a straight line
(b) circle

(c) line without rotation
(d) curved path

ii. The motion of a body about an axis is called

(a) circular motion
(b) rotatory motion
(c) vibratory motion
(d) random motion

iii. Which of the following is a vector quantity?

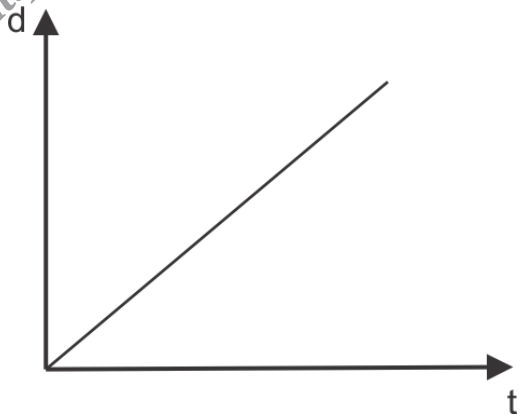
(a) Speed (b) distance (c) displacement (d) power

iv. If the object is moving with constant speed then its distance- time graph will be a straight line.

(a) along time- axis
(b) along distance-axis
(c) parallel to time-axis
(d) inclined to time-axis

Explanation:

Distance time graph for constant speed is shown in following figure:

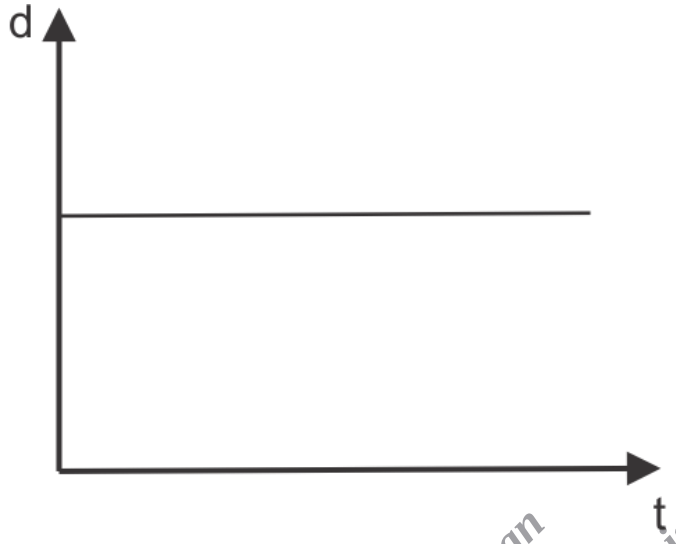


v. A straight line parallel to time- axis on a distance – time graph tells that the object is

(a) moving with constant speed
(b) at rest

(c) moving with variable speed
(d) in motion

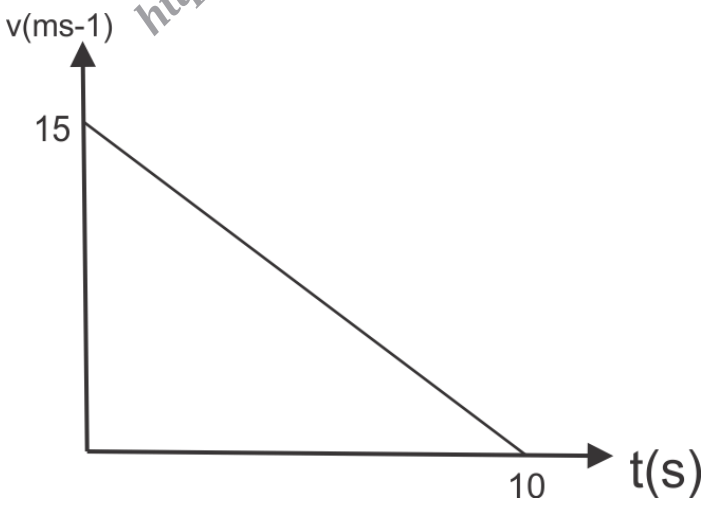
Explanation:



Distance-time graph when the object is at rest

vi. The speed- time graph of a car shown in the figure, which of the following statement is true?

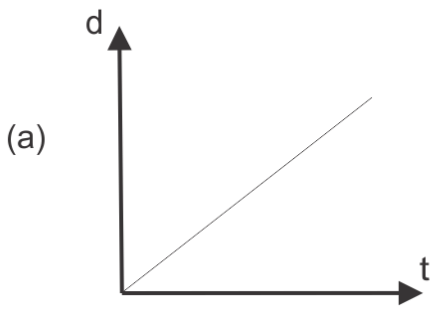
(a) car has an acceleration of 1.5 ms^{-2}
(b) car has constant speed of 7.5 ms^{-1}
(c) distance travelled by the car is 75 m.
(d) Average speed of the car is 15 ms^{-1}

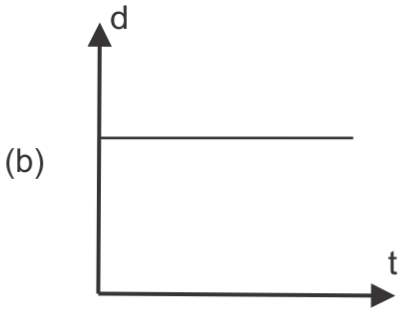


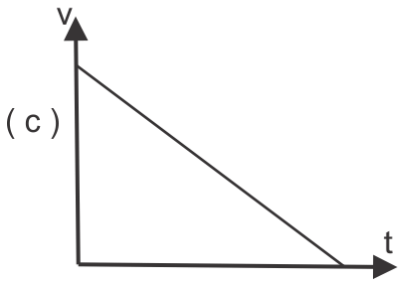
Speed-time graph for of a car

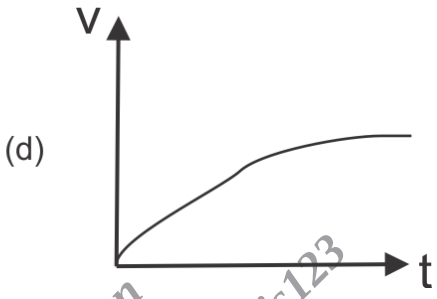
Explanation:

vii. Which of the following graphs is representing uniform acceleration?









viii. By dividing displacement of a moving body with time, we obtain

(a) speed (b) acceleration (c) velocity (d) deceleration

ix. A ball is thrown vertically upward. Its velocity at the highest point is:

(a) -10 ms^{-1} (b) zero (c) 10 ms^{-2} (d) none of these

x. A change in position is called:

(a) speed (b) velocity (c) displacement (d) distance

xi. A train is moving at a speed of 36 kmh^{-1}. Its speed expressed in ms^{-1} is:

(a) 10 ms^{-1} (b) 20 ms^{-1} (c) 25 ms^{-1} (d) 30 ms^{-1}

Explanation:

$v = 36\ kmh^{-1}$

$$v = \frac{36 \times 1000}{3600} ms^{-1}$$

$$v = 10 ms^{-1}$$

xii. A car starts from rest. It acquires a speed of 25 ms^{-1} after 20 s. The distance moved by the car during this time is:

(a) 31.25 m (b) 250 m (c) 500 m (d) 5000 m

Explanation:

Given that

$v_i = 0$, $v_f = 25\ ms^{-1}$, $t = 20\ s$

$S = ?$

We know that

$v_f = v_i + at$

$25ms^{-1} = 0 + a \times 20\ s$

$$a = \frac{25ms^{-1}}{20\ s} = \frac{5}{4}\ ms^{-2}$$

We know that

$$S = v_i t + \frac{1}{2} at^2$$

$$S = 0 \times 20\ s + \frac{1}{2} \times \frac{5}{4}\ ms^{-2} \times (20s)^2$$

$$S = 0 + \frac{5}{8}\ ms^{-2} \times 400s^2$$

$S = 5 \times 50\ m$

$S = 250\ m$

Ans:

i. c ii. b iii. c iv. d v. b vi. c vii. c viii. c ix. b x. c xi. a xii. b

Exercise Short Questions

Q. 2.3 (i) Differentiate between rest and motion.

Ans.

Sr.#	Rest	Motion
i.	A body is said to be at rest if it does not change its position with respect to its surroundings.	A body is said to be in motion, if it changes its position with respect to its surroundings.
ii.	**Example:** A passenger inside a moving bus is at rest with respect to other passengers or objects in the bus.	**Example:** A passenger inside a moving bus is in motion with respect to other persons outside the bus.

(ii) Differentiate between circular motion and rotatory motion.

Ans.

Sr.#	Circular motion	Rotatory motion
i.	The motion of an object in a circular path is known as circular motion.	The spinning motion of a body about its axis is called its rotatory motion.
ii.	**Example:** The motion of aeroplanes flying straight in air.	**Example:** The motion of a wheel about its axis.

(iii)Differentiate between distance and displacement.

Ans.

Sr.#	Distance	Displacement
i.	Length of a path between two points is called the distance between those points.	Displacement is the shortest distance between two points which has magnitude and direction.
ii.	It is a scalar quantity.	It is a vector quantity.
iii.	It is represented by 'S'	It is represented by'd'.
iv.	Its formula is: $S = v\,t$ Where 'v' is speed of a body and't' is time taken by it.	Its formula is : $d = v\,t$ Where ' v ' is velocity of a body and 't' is time taken by it.

(iv)Differentiate between speed and velocity.

Ans.

Sr.#	Speed	Velocity
i.	Distance covered by an object in unit time is called its speed.	The rate of displacement of a body is called its velocity.
ii.	It is a scalar quantity.	It is vector quantity.

iii.	Its formula is : $\text{Speed} = \frac{\text{distance covered}}{\text{time taken}}$ $v = \frac{S}{t}$	Its formula is : $\text{Velocity} = \frac{\text{displacement}}{\text{time taken}}$ $v = \frac{d}{t}$

(v) Differentiate between linear and random motion.

Ans.

Sr.#	Linear motion	Random motion
i.	Straight line motion of a body is known as its linear motion.	The disordered or irregular motion of an object is called random motion.
ii.	**Example:** Aeroplanes flying in straight in air.	**Example:** The motion of dust or smoke particles in the air.

(vi)Differentiate between scalars and vectors.

Ans.

Sr.#	Scalars	Vectors
i.	Physical quantities which can be completely described by their magnitude are called scalars.	Physical quantities which can be described completely by magnitude along with their direction.
ii.	**Examples:** Mass, length and time etc.	**Example:** Velocity, force and displacement etc.

Q.2.4 Define the term speed, velocity, and acceleration.

Ans. Speed: "The distance covered by an object in unit time is called its speed." It is a scalar quantity. It is represented by "v".

Formula: $\text{Speed} = \frac{\text{distance covered}}{\text{time taken}}$

$$v = \frac{S}{t}$$

SI unit of speed is meter per second (ms^{-1}).

Velocity: "Distance covered by an object in unit time is called its speed."

It is a scalar quantity. Its formula is:

$$\text{Velocity} = \frac{\text{displacement}}{\text{time taken}}$$

$$v = \frac{d}{t}$$

SI unit of velocity is meter per second (ms^{-1}).

Acceleration: "The rate of change of velocity of a body is called its acceleration."

It is a vector quantity. It is represented by 'a'. Its SI unit is meter per second per second (ms^{-2}).

Its formula is:

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

$$\text{Acceleration} = \frac{\text{final velocity-initial velocity}}{\text{time taken}}$$

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

Q.2.5 Can a body moving at a constant speed have acceleration.

Ans. A body moving at constant speed has acceleration because the magnitude of velocity is constant but its direction may be changing. So velocity is changing. Rate of change of velocity is called acceleration.

For example, when an object moves along a circle with constant speed, its velocity changes due to change in direction continuously.

Q.2.6 How do riders in a Ferris wheel possess translator motion but not rotatory motion but not rotatory motion?

Ans. Riders in a Ferris wheel moves in a circular path. The motion of an object in circular path is known as circular motion. Circular motion is a translator motion. So riders in a Ferris wheel possess translator motion but not rotatory motion.

Q.2.7 Sketch a distance-time graph for a body starting from rest. How will you determine the speed of a body from this graph?

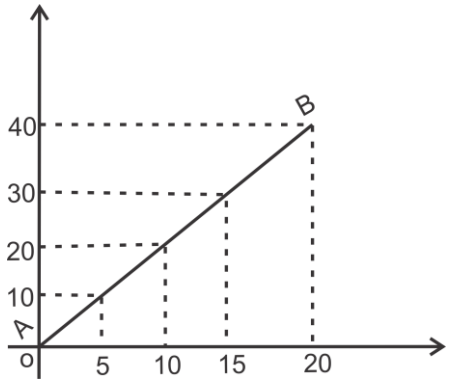
Ans. When an object is moving with constant speed, the distance-time graph is a straight line as shown in the figure. Its slope gives the speed of the object.

Slope of line AB = $\frac{BC}{AC}$

Slope of line AB= $\frac{40m}{20s}$

Speed of object= Slope of line AB

Speed of object= $2ms^{-1}$



Q.2.8 What would be the shape of a speed- time graph of a body moving with variable speed?

Ans. When an object does not cover equal distance in equal interval of time then its speed is variable. The distance-time graph for variable speed is not a straight line as shown in figure (b) .

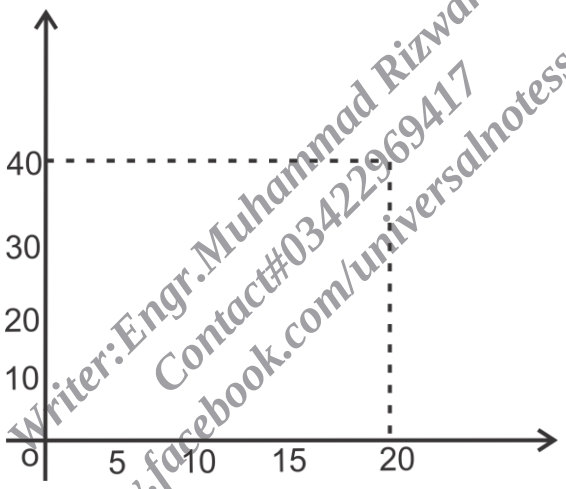


Figure (b): Distance-time graph showing variable speed

Q.2.9 Which of the following can be obtained from speed – time graph of a body?

(i) Initial speed (ii) Final speed (iii) Distance covered in time t

(iv)Acceleration of motion

Ans. We can calculate initial speed, final speed, distance covered in time t and acceleration of motion from speed- time graph of a body.

Q.2.10 How can vector quantities be represented graphically?

Ans. Graphically a vector can be represented by a line segment with an arrow head. The length of line segment gives the magnitude of the vector. In figure (a) the line AB with arrow head at B represents a vector V. The length of the line AB gives the

magnitude of the vector V on selected scale. While the direction of the line from A to B gives the direction of the vector V.

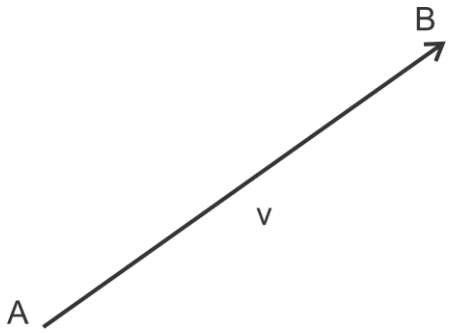


Figure (a): Graphical representation of a vector V.

Q.2. 11 Why vector quantities cannot be added and subtracted scalar quantities?

Ans. Vector quantities cannot be added and subtracted like scalar quantities because these are two different physical quantities. Vectors have magnitude and direction but scalars have magnitude only. Due to direction of vectors, we use a separate method which is known as Head-to- Tail rule for addition and subtraction of vectors.

Q.2.12 How are vector quantities are important to us in our daily life?

Ans. Vector quantities are very important to us in our daily life. Vectors are used to solve mathematical problems in physics and mathematics. We can get full information about a quantity as both its magnitude and direction are given. Vector quantities are applied on cricket, sports and travelling etc.

Q.2.13 Sketch a velocity time graph for the motion of the body .From the graph explaining each step, calculate total distance covered by the body.

Ans. Velocity-time graph for the motion of the body is shown in figure (a)

Distance covered by the body= Area of rectangle OABC

$$S = OC \times OA$$

$$S = 20s \times 6\ ms^{-1}$$

$$S = 120m$$

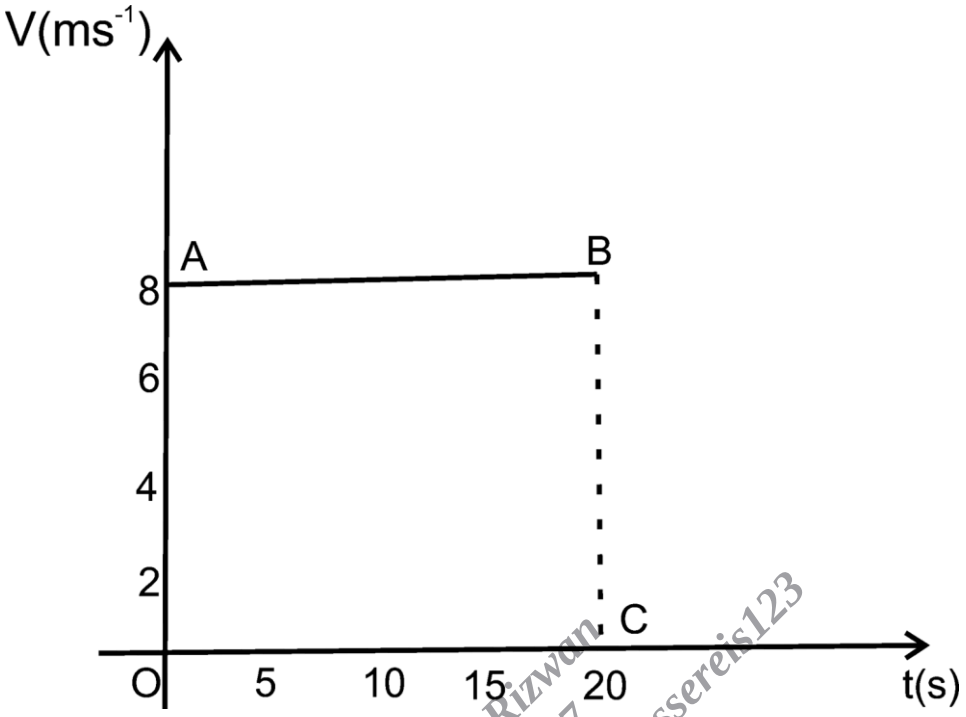


Figure (a): Speed-time graph showing constant speed

Important Formula, units and values for Problems

Equations of motion:

$$v_f = v_i + at \quad , S = v_i t + \frac{1}{2} at^2 \quad \text{and} \quad 2aS = v_f^2 - v_i^2$$

We use above equation when anything (car, train etc.) moving with uniform acceleration on the road.

Equations of motion under gravity:

$$v_f = v_i + gt \quad , h = v_i t + \frac{1}{2} gt^2 \quad \text{and} \quad 2gh = v_f^2 - v_i^2$$

We use above equations when we throw anything (stone or ball etc.) in upward or downward direction.

$$g = 10\ ms^{-2}$$

$$S = vt \quad , a = \frac{v_f - v_i}{t}$$

When a ball or stone is thrown in upward direction, we take

Final velocity $v_f = 0$, $g = -10\ ms^{-2}$

When a ball is thrown in downward direction, we take

Initial velocity $v_i = 0$, $g = 10\ ms^{-2}$

Problems

2.1 A train is moving with uniform velocity of 36 kmh^{-1} for 10s. Find the distance travelled by it.

Given Data:

Velocity = $v = 36kmh^{-1}$

$$= \frac{36 \times 1000}{3600} ms^{-1}$$

$v = 10ms^{-1}$

Time = $t = 10s$

Required:

Distance = $S' = ?$

Solution:

We know that

$S = vt$

$S = 10ms^{-1} \times 10s$

$S = 100m$

2.2 A train starts from rest. It moves through 1 km in 100s with uniform acceleration. What will be its speed at the end of 100s.

Given Data:

Initial velocity = $v_i = 0$

Distance = $S = 1km$

$S = 1 \times 1000m$

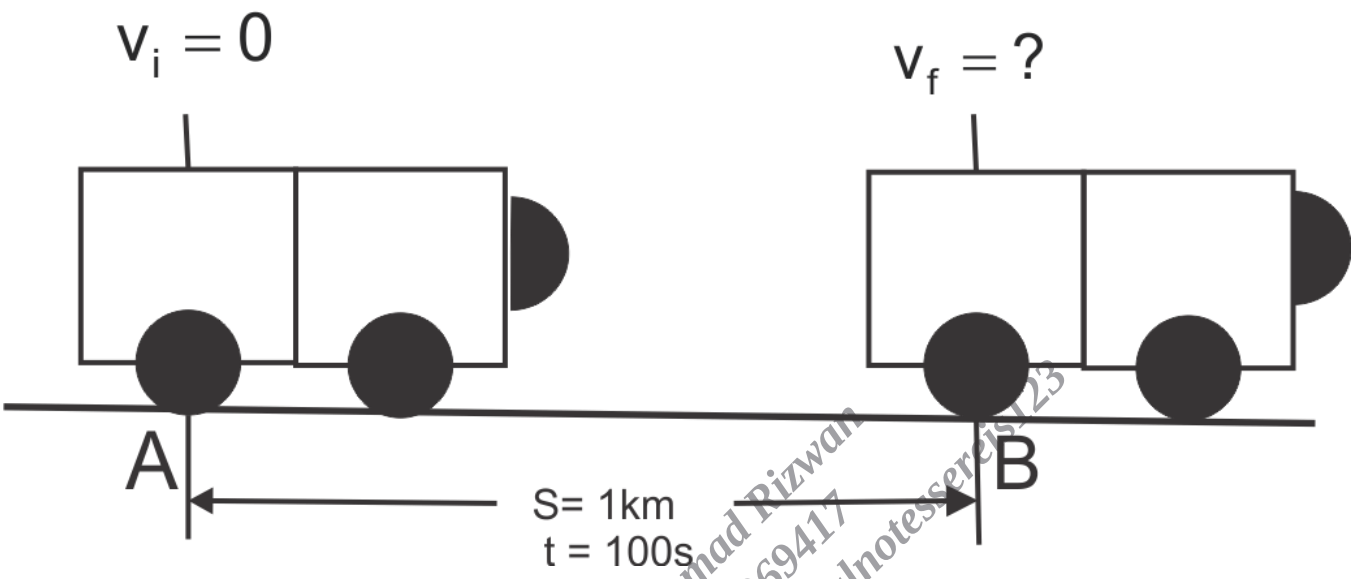
$S = 1000m$

Time = $t = 100s$

Required:

Final velocity = v_f =?

Solution:



We know that

$$S = v_i + \frac{1}{2}at^2$$

$$1000m = (0)100s + \frac{1}{2}a(100s)^2$$

$$1000m = 0 + \frac{a(10000s^2)}{2}$$

$$1000m = a(500s^2)$$

$$\frac{1000m}{5000s^2} = a$$

$$a = 0.2ms^{-2}$$

We know that

$$v_f = v_i + at$$
$$v_f = 0 + 0.2ms^{-2} \times 100s$$
$$v_f = 20ms^{-2+1}$$
$$v_f = 20ms^{-1}$$

2.3 A car has a velocity of 10 ms^{-1}.It accelerated at 0.2 for half minute. Find the distance travelled during this time and the final velocity of the car.

Given Data:

Initial velocity = $v_i = 10ms^{-1}$
Acceleration = $a = 0.2ms^{-2}$
Time = $t = \frac{1}{2}min = \frac{1}{2} \times 60s = 30s$

Required:

Distance = S =?
Final velocity = v_f =?

Solution:

We know that

$$S = v_i t + \frac{1}{2}at^2$$

$$S = 10ms^{-1} \times 30s + \frac{1}{2} \times 0.2ms^{-2} \times (30s)^2$$

$$= 300m + \frac{1}{2} \times 0.2ms^{-2} \times 900s$$

$$= 300m + 90m$$

$$S = 300m + 90m$$

$$S = 390m$$

We know that

$$v_f = v_i + at$$
$$v_f = 10ms^{-1} + 0.2ms^{-2} \times 30s$$
$$v_f = 10ms^{-1} + 6ms^{-2+1}$$
$$v_f = 10ms^{-1} + 6ms^{-1}$$
$$v_f = 16ms^{-1}$$

2.4 A tennis ball is hit vertically upward with a velocity of 30 ms^{-1}.It takes 3s to reach the highest point. Calculate the maximum height reached by the ball. How long it will take to return to ground?

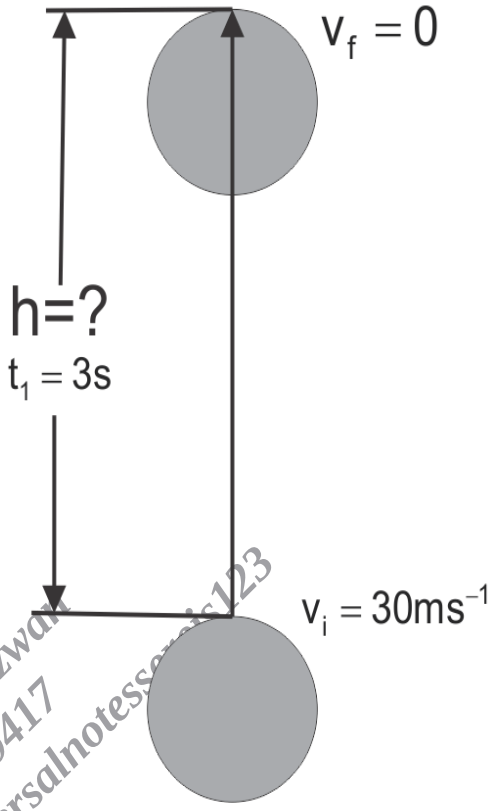
Given Data:

Initial velocity = $v_i = 30ms^{-1}$
Final velocity = $v_f = 0$

Time taken to reach at maximum height = $t_1 = 3s$
Gravitational acceleration = $g = 10ms^{-2}$

Required:

Maximum height = h =?
Total time = t =?



Solution:

We know that

$$2gh = v_f^2 - v_i^2$$
$$2(-10ms^{-2})h = (0)^2 - (30ms^{-1})^2$$
$$-20ms^{-2}h = 0 - 900m^2s^{-2}$$
$$h = -900m^2s^{-2}$$
$$h = \frac{-900m^2s^{-2}}{-20ms^{-2}}$$
$$h = 45m$$

As acceleration due to gravity is uniform, hence the time t_1 taken by the ball to go up t_2 taken to come down.

$t_2 = t_1$
$t_2 = 3s$
We know that
$t = t_1 + t_2$

$t = 3s + 2s$
$t = 6s$

2.5 A car moves with uniform velocity of 40 ms^{-1} for 5s. It comes to rest in next 10s with uniform deceleration. Find (i) deceleration (ii) total distance travelled by the car.

Given Data:

Initial velocity = $v_i = 40ms^{-1}$
Time = $t_1 = 5s$
Time = $t_2 = 10s$
Final velocity = $v_f = 0$

Required:

Deceleration = a =?
Total distane = S =?

Solution:

We know that

$v_f = v_i + at$
$0 = 40ms^{-1} + a(10s)$ $(\because t = t_2)$
$-40ms^{-1} = 10sa$
$\frac{-40ms^{-1}}{10s} = a$
We know that
$S = vt$
$S_1 = vt_1$
$S_1 = 40ms^{-1} \times 5s$
$S_1 = 200m$
We know that
$2as = v_f^2 - v_i^2$
$2(-4ms^{-2})S_2 = (0)^2 - (40ms^{-1})^2$
$-8ms^{-2}S_2 = 0 - 1600m^2s^{-2}$
$S_2 = \frac{-1600m^2s^{-2}}{-8ms^{-2}}$
$S_2 = 200m$

We know that
$S = S_1 + S_2$
$S = 200m + 200m$
$S = 400m$

2.6 A train starts from rest with an acceleration of 0.5 ms^{-2}. Find its speed in kmh^{-1}, when it has moved through 100m.

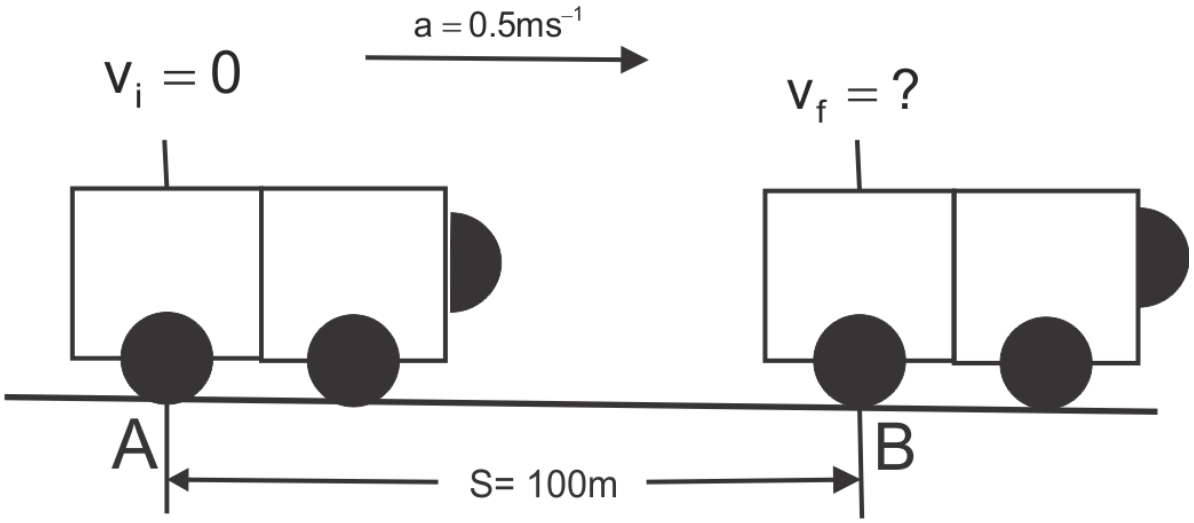
Given Data:

Initial velocity = $v_i = 0$
Acceleration = $a = 0.5ms^{-2}$
Distance = S = 100m

Required:

Final velocity in kmh^{-1} = v_f =?

Solution:



We know that

$2as = v_f^2 - v_i^2$

$2 \times 0.5ms^{-2} \times 100m = v_f^2 - (0)^2$

$100m^2s^{-2} = v_f^2$

$\sqrt{v_f^2} = \sqrt{100m^2s^{-2}}$

$v_f = 10ms^{-1}$

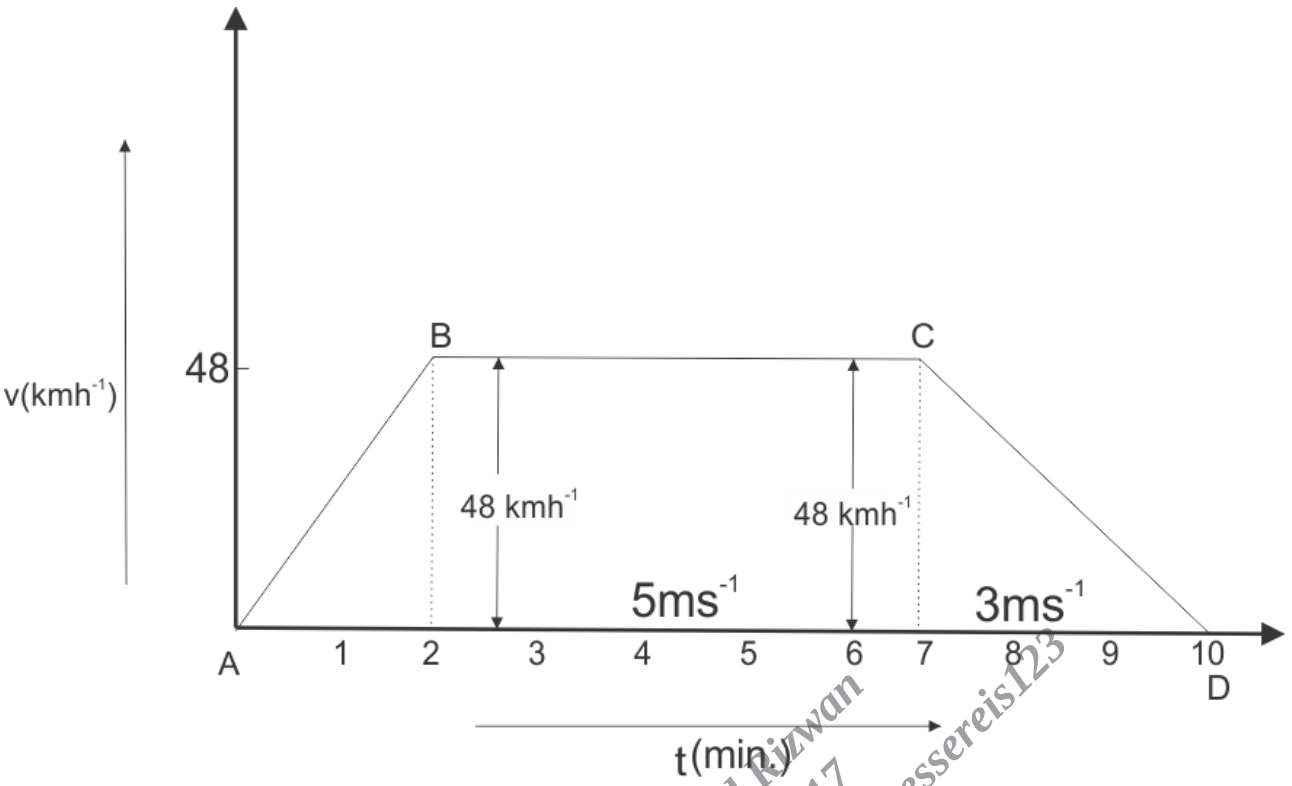
$v_f = \frac{10 \times 3600}{1000} kmh^{-1}$

$v_f = 36kmh^{-1}$

2.7 A train starting from rest accelerates uniformly and attains a velocity 48 kmh^{-1} in 2 minutes. It travels at this speed for 5 minutes. Finally, it moves with uniform retardation and is stopped after 3 minutes. Find the total distance travelled by the train.

Given Data:

Speed-time graph for the motion of train is shown in following figure:



Required:

Total distance travelled = S =?

Solution:

Total distance = Area of trapezium ABCD

$S = \frac{1}{2}$(sum of parallel sides) × (Distanc b/w them)

$S = \frac{1}{2}(|AD| + |BC|) \times |BE|$

$S = \frac{1}{2}(10\text{min} + 5\text{min}) \times 48\text{kmh}^{-1}$

$= \frac{1}{2}(15\text{min}) \times 48\text{kmh}^{-1}$

$= \frac{1}{2} \times 15 \times 16\text{s} \times \frac{48 \times 1000\text{m}}{3600\text{s}}$

$= \frac{1}{2} \times 900 \times \frac{40}{3}\text{m}$

S = 6000m

2.8 A cricket ball is hit vertically upwards and returns to ground 6s later. Calculate (i) maximum height reached by the ball. (ii) initial velocity of the ball

Given Data:

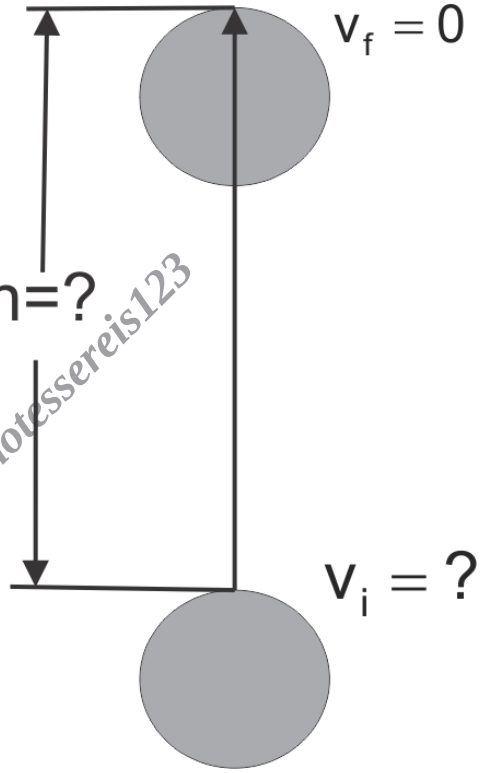
Acceleration due to gravity = g = $-10ms^{-2}$

Total time = t = 6s

Time taken to reach at maximum height = $t_1 = \frac{t}{2}$

$t_1 = \frac{6s}{2}$

$t_1 = 3s$



Required:

Maximum height = h =?

Initial velocity = v_i =?

Solution:

We know that

$v_f = v_i + gt$

$0 = v_i + (-10ms^{-2}) \times 3s$ ($\because t = t_1$)

$0 = v_i - 30ms^{-2+1}$

$0 = v_i - 30ms^{-1}$

$v_i = 30ms^{-1}$

We know that

$2gh = v_f^2 + v_i^2$

$2(-10ms^{-2})h = (0)^2 - (30ms^{-1})^2$

$-20ms^{-2}h = -900m^2s^{-2}$

$h = \frac{-900m^2s^{-2}}{-20ms^{-2}}$

$h = 45m$

2.9 When brakes are applied, the speed of a train decreases from $96kmh^{-1}$ to $48\ kmh^{-1}$ in 800m. How much further will the train move before coming to rest (Assuming the retardation to be constant).

Given Data:

$v_i = 96kmh^{-1}$

$= \frac{96 \times 1000ms^{-1}}{3600}$

$v_i = 26.67ms^{-1}$

$v_f = 48kmh^{-1} = \frac{48 \times 1000}{3600} ms^{-1}$

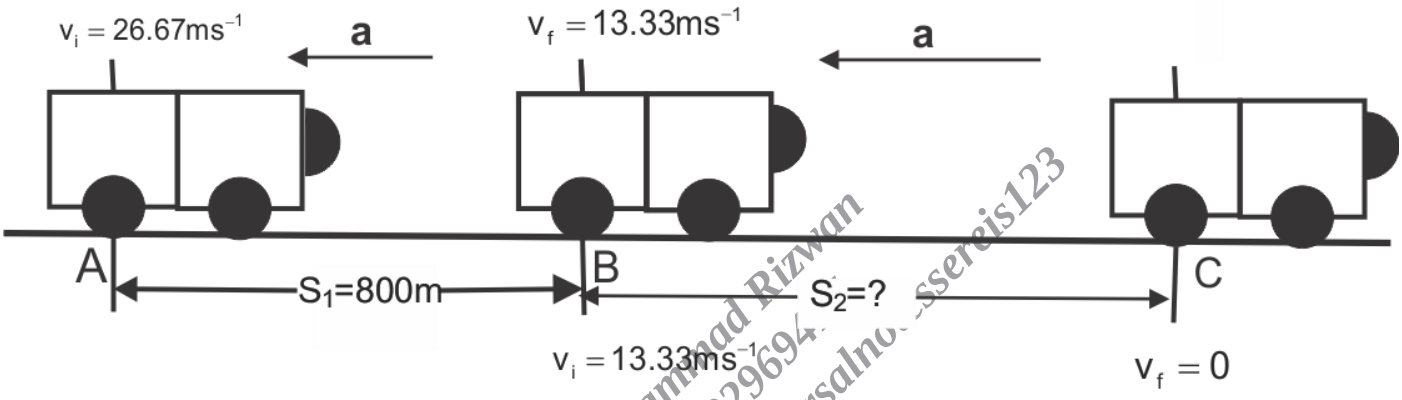
$v_f = 13.33ms^{-1}$

$S_1 = 800m$

Required:

Distance covered by train before coming to rest = S_2 =?

Solution:



We know that

$2aS = v_f^2 - v_i^2$

$2a(800m) = (13.33ms^{-1})^2 - (26.67ms^{-1})^2$

$1600a = 177.6889m^2s^{-2} - 711.2889m^2s^{-2}$

$1600ma = -533.6\ m^2s^{-2}$

$a = \frac{-533.6m^2s^{-2}}{1600m}$

$a = -0.3335ms^{-2}$

We know that

$2as = v_f^2 - v_i^2$

$2(-0.3335ms^{-2})S_2 = (0)^2 - (13.33ms^{-1})^2$

$-0.6670ms^{-2} \times S_2 = -177.6889\ m^2s^{-2}$

$S_2 = \frac{-177.6889m^2s^{-2}}{-0.6670m}$

$S_2 = 266.40ms^{-2}$

2.10 In the above problem, find the time taken by the train to stop after application of brakes.

Given Data:

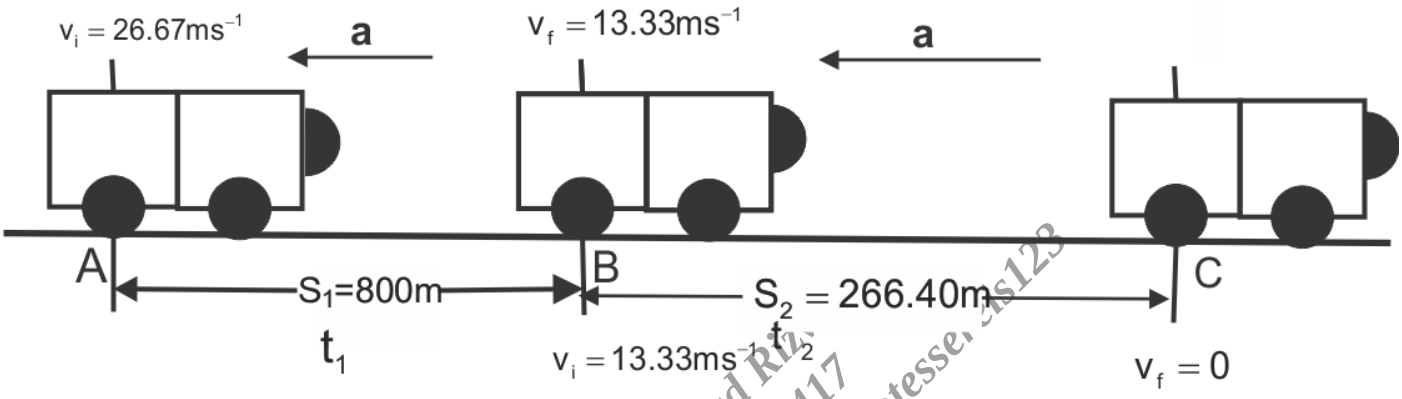
$v_i = 26.67ms^{-1}$
$v_f = 0ms^{-1}$

$a = -0.333ms^{-2}$

Required:

Total Time = t =?

Solution:



We know that

$v_f = v_i + at$
$13.33ms^{-1} = 26.67ms^{-1} + (-0.333ms^{-2})t_1$
$-13.33ms^{-1} - 26.67ms^{-1} = -0.333ms^{-2} \times t_1$
$-13.34ms^{-1} = -0.333ms^{-2}t_1$
$\frac{-13.34ms^{-1}}{-0.333ms^{-2}} = t_1$
$40s = t_1$
$t_1 = 40s$

We know that

$v_f = v_i + at$
$v_f = v_i + at_2$
$0 = 13.33ms^{-1} + (-0.333)t_2$
$-13.333\ ms^{-1} = -0.333t_2$
$40s = t_2$

Total Time = $t = t_1 + t_2$
$t = 40s + 40s$
$t = 80s$

3 Dynamics

Q.3.1 Encircle the correct answer from the given choices

i. Newton's first law of motion is valid only in the absence of:
(a) force (b) net force (c) friction (d) momentum

ii. Inertia depends upon

(a) force (b) net force (c) mass (d) velocity

ii. A boy jumps out of a moving bus. There is danger for him to fall:
(a) towards the moving bus
(b) away from the bus
(c) in the direction of motion
(d) opposite to the direction of motion

iii. A string is stretched by two equal and opposite forces 10N each. The tension in the string is
(a) zero (b) 5N (c) 10 N (d) 20 N

iv. The mass of a body :
(a) decreases when accelerated
(b) increases when accelerated
(c) decreases when moving with high velocity
(d) none of the above

v. Two bodies of mass m_1 and m_2 attached to the ends of an inextensible string passes over a frictionless pulling such that both move vertically. The acceleration of the bodies is:
(a) $\frac{m \times m}{m+m}$ g (b) $\frac{m-m}{m+m}$ g (c) $\frac{m+m}{m-m}$ g (d) $\frac{2m\,m}{m+m}$ g

vi. Which of the following is the unit of momentum?
(a) Nm (b) $kgms^{-2}$ (c) Ns (d) Ns^{-1}

Explanation:

We know that P = mv

SI unit of P= kg ms^{-1}

SI unit of P= kg $ms^{-1} \times s^{-1} \times s$

SI unit of P= kg $ms^{-2} \times s$

SI unit of P= N s $(\therefore 1N = 1kgms^{-2})$

vii. When horse pulls a cart, the action is on the:
(a) cart (b) Earth (c) horse (d) Earth and cart

viii. Which of the following material lowers friction when pushed between metal plates?
(a) water (b) fine marble powder (c) air (d) oil

Ans:

i. c ii. c iii. c iv. c v. d vi. b vii. c viii. b ix. d

Exercise Short Questions

Q.3.2 (i) Define inertia.

Ans. Inertia: "Inertia of a body is its property due to which it resists any change in its state of rest motion." Inertia depends upon the mass of a body. Greater is the mass of a body greater is its inertia.

(ii) Define momentum.

Ans. Momentum: "Momentum of a body is the quantity of motion it possess due to its mass and velocity." It is a vector quantity. Its SI unit is $kgms^{-1}$ or N s.

Its formula is :

Momentum = mass × velocity

$P = m V$

(iii) Define force.

Ans. Force: "An agency which moves or tends to move, stop or tends to stop the motion of a body is called force." Force is a vector quantity. Its SI unit is newton (N).

Formula is:

$F = ma$

(iv)Define force of friction.

Ans. Force: "The force that opposes the motion of moving objects is called friction." It is vector quantity. Its SI unit is newton (N).

(v) Define centripetal force.

Ans. Centripetal Force: "Centripetal force is a force that keeps a body to move in a circle." Its direction is towards the centre of a circle. It is represented by F_c.

Its formula is:

$$F_c = \frac{m\,v^2}{r}$$

Q.3.3 (i) Differentiate between mass and weight

Ans.

Sr.#	Mass	Weight
i.	Mass of a body is the quantity of matter possessed by the body.	Weight of a body is the force of gravity acting on it.
ii.	It is a scalar quantity.	It is a vector quantity.
iii.	It is represented by 'm'	It is represented by 'w'
iv.	Its formula is: $m = \frac{w}{g}$	Its formula is: $W = mg$
v.	Its SI unit is kilogramme (Kg)	Its SI unit is newton (N)
vi.	It does not change with the change in the position on the Earth's surface.	It changes with the change in the position on the Earth's surface.
vii.	It is measured by a beam balance.	It is measured by a spring balance.

(ii) Differentiate between action and reaction.

Ans.

Sr.#	Action	Reaction
i.	The applied force exerted by first body on the second body is called action	The force exerted by second body on the first body due to action is called reaction.
ii.	Action is opposite to reaction.	Reaction is opposite to action.

(iii) Differentiate between sliding friction and rolling friction.

Ans.

Sr.#	Sliding friction	Rolling friction
i.	The force of friction between sliding body and the surface over which it slides is called sliding friction.	The force of friction between rolling body and the surface over which it rolls is called rolling friction.

ii.	In sliding friction, very large area of the two surfaces is in contact with each other.	In rolling friction, very small area of the two surfaces is in contact with each other.
iii.	In sliding friction, motion is produced by rupturing the cold welds.	In rolling friction, motion is produced without rupturing the cold welds.
iv.	Sliding friction is greater than rolling friction	Rolling friction is much less than sliding friction
v.	It increases loss of energy.	It decreases loss of energy.

Q.3.4 What is the law of inertia?

Ans. Newton's first law of motion deals with the inertial property of matter, therefore, Newton's first law of motion is also known as law of inertia.

It states that:

"A body continues its state of rest or uniform motion in a straight line provided no net force act on it."

Q.3.5 Why is it dangerous to travel on the roof of a bus?

Ans. Travelling on the roof of a bus is very dangerous because when a bus stops at once, due to inertia the passengers continue their motion in straight line. Thus, they fall in the forward direction.

Q.3.6 Why does a passenger move outward when a bus takes a turn?

Ans. When a bus takes a sharp turn, passengers fall in the outward direction. Due to inertia the passengers continue their motion in a straight line and fall outwards.

Q.3.7 How can you relate a force with the change of momentum of a body?

Ans. Long question (Page # 67 topic force and momentum)

Q.3.8 What will be the tension in a rope that is pulled from its ends by two opposite forces 100N each?

Ans. Tension in string will be equal to 100N.

Q.3.9 Action and reaction are always equal and opposite. Then how does a body moves?

Ans. Action and reaction act on different bodies. They do not balance each other. Action is on the one body and reaction is on the other body. As action and reaction are equal in magnitude but opposite in direction, thus a body moves.

Q.3.10 A horse pushes the cart. If the action and reaction are equal and opposite. Then how does a body moves?

Ans. A horse apply action force by feet on the road, the reaction is given by roads on horse, due to which horse moves. The cart which is tied with the horse also moves.

Q.3.11 What is the law of conservation of momentum?

Ans. Law of conservation of momentum states:

"The momentum of an isolated system of two or more than two interacting bodies remains constant."

An isolated system is group of interacting bodies on which no external force is acting.

Q.3.12 Why is the law of conservation of momentum important?

Ans. By using law of conservation of momentum it is possible to calculate force, velocity and acceleration of a body. Most of elementary particles are discovered by the use of this law.

Q.3.13 When a gun is fired, it recoils. Why?

Ans. Before firing the gun, total momentum of the system (gun and bullet) is zero. So after firing the gun total momentum must be zero. That is why the gun recoils to conserve the momentum of the system.

Q.3.14 Describe two situations in which force of friction is needed.

Ans. Friction plays very important role in our daily lives.

(i) Friction is needed to hold a pen and to write a word on your notebook.
(ii) Friction is needed to walk on the ground. We cannot run on slippery ground.

Q.3.15 How does oiling the moving parts of a machine lowers friction?

Ans. Oil is a lubricant. Its use makes the surfaces a little plane and smooth. Thus, oiling the moving parts of a machine lowers the friction.

Q.3.16 Describe ways to reduce friction.

Ans. Friction can be reduced by following methods:

(i) making the sliding surfaces smooth.

(ii) Making the fast moving objects a streamline shape (fish shape) such as cars, aero planes etc.
(iii) Lubricating the sliding surfaces.
(iv) Using ball bearing or roller bearing.

Q.3.17 Why rolling friction is less than sliding friction?

Ans. Sliding surfaces moves over each other after rupturing the cold welds, thus producing greater friction. While the wheels roll without rupturing the cold welds producing lesser friction. That is why the rolling friction is less than sliding friction.

Q.3.18 (i) What do you know about tension in a string?

Ans. " The force which is exerted by the string on the body is called tension in the string." It is a reaction force . It is denoted by 'T'.

(ii)What do you know about the limiting force of friction?

Ans. "The maximum value of friction is known as limiting force of friction." It is denoted by F_s .Its formula is:

$$F_s = \mu R$$

(iii) What do you know about braking force?

Ans. The braking is a force between brakes bushes and wheels of vehicles. It helps to stop wheels.

(iv)What do you know about the skidding of vehicles?

Ans. When a vehicle stops quickly, a large force of friction is needed. But there is a limit to this force of friction that tyres can provide. If the brakes are applied too strongly, the wheels of the car will lock up (rupturing) and vehicle slide over the road .It is called skidding of vehicles.

(v)What do you know about seatbelts?

Ans. A seat belt, also known as a safety belt, is a vehicle safety device designed to secure the occupant of a vehicle against harmful movement that may result during a collision or sudden stop.

(vi)What do you know about the banking of roads?

Ans. "Banking of a road means that outer edge of a road is raised." Banking causes a component of vehicle's weight to provide the necessary centripetal force while taking a turn. Thus banking of the roads prevents skidding and makes the driving safe.

(vii) What do you know about cream separator?

Ans. In cream separator, the bowl spins at very high speed, the heavier contents of milk moves outward in the bowl. The lighter contents such as cream or butterfat push inwards towards the spinning axis. Therefore, skimmed milk which is denser than cream is collected at the outer wall of the bowl. The lighter contents are pushed towards the centre from where it is collected through a pipe.

Q.3.19 What would happen if all friction suddenly disappear?

Ans. Without friction, life would be impossible. Raising a glass of water to your lips, to write a word in your notebook or to play in ground would be distant dream. You could forget about driving your car down the street even walking across the road would be tricky.

Q.3.20 Why the spinner of a washing machine is made to spin at a very high speed?

Ans. When the spinner of a washing machine is made to spin at very high speed, the centripetal force decreases. Due to centrifugal force, water from wet clothes extracted.

Important Formula, units and values for Problems

$w = mg$, $F = ma$, $F = \frac{\Delta P}{t}$

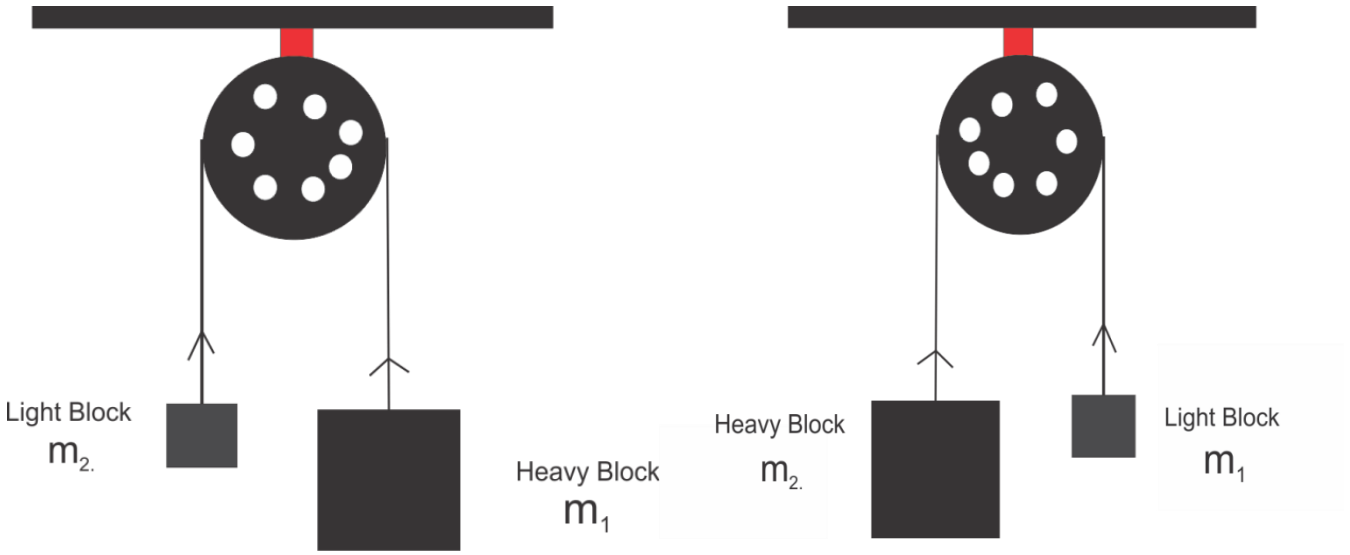
$f = \mu mg$, $F_c = \frac{mv^2}{r}$

SI unit of force (F), force of friction (f) is newton (N).

$1N = kgms^{-2}$, $g=10\ ms^{-2}$

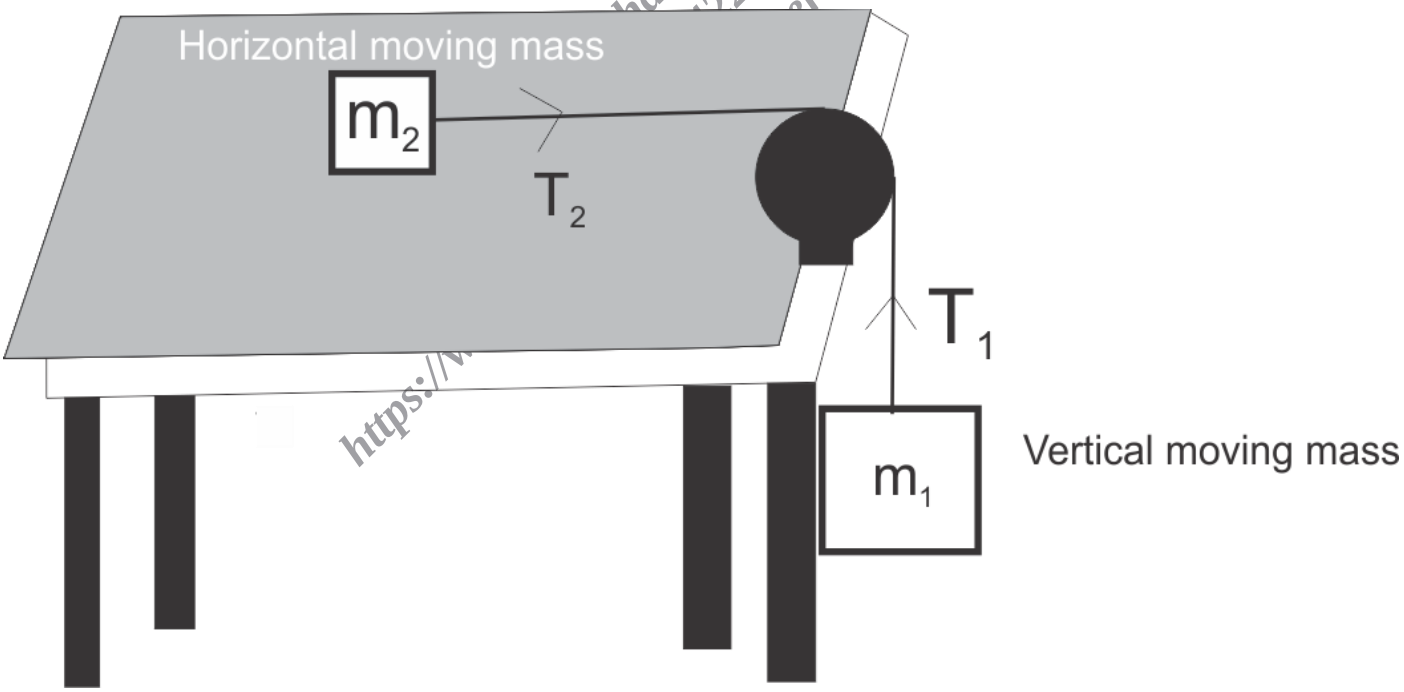
In vertical motion of two bodies attached to the end of a string that passes over a frictionless pulley, heavy mass is taken as m_1 and light mass is taken as m_2:

$$T = \frac{2m_1m_2}{m_1+m_2} \quad , \quad a = \frac{m_1-m_2}{m_1+m_2}g$$



In motion of two bodies attached to the ends of a string that passes over frictionless pulley such that one body moves vertically that is taken as m_1 and the other moves a smooth horizontal surface that is taken as m_2:

$$a = \frac{m_1}{m_1 + m_2} g \quad , \quad T = \frac{m_1 m_2}{m_1 + m_2} g$$



Problems

3.1 A force of 20 N moves a body with an acceleration of $2ms^{-2}$.What is its weight?

Given Data:

Force = F = 20N

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

Required:

Mass of the body = m =?

Solution:

We know that

$$F = ma$$

$$\frac{F}{a} = m$$

$$m = \frac{F}{a}$$

$$m = \frac{20N}{2ms^{-2}}$$

$$m = \frac{10Kgms^{-2}}{ms^{-2}} \quad (\because 1N = 1Kgms^{-2})$$

$$m = 10Kg$$

3.2 The weight of a body is 147 N. What is its mass? (Take the value of g as 10 ms^{-2}.

Given Data:

Weight = w = 147N

Required:

Mass = m = ?

Solution:

We know that,

$$w = mg$$

$$\frac{w}{g} = m$$

$$m = \frac{147N}{10ms^{-2}}$$

$$m = \frac{147Kgms^{-2}}{10ms^{-2}} \quad (\because 1N = 1Kgms^{-2})$$

$$m = 14.7Kg$$

3.3 How much force is needed to prevent a body of mass 10 kg from falling?

Given Data:

Mass of the body = m = 10Kg

Required:

Force needed to prevent a body from falling = F =?

Solution:

Force needed to prevent a body from falling is equal to its weight

$F = w$

$F = mg$

$F = 10Kg \times 10ms^{-2}$

$F = 100Kgms^{-2}$

$F = 100N \quad (\therefore 1N = 1Kgms^{-2})$

3.4 Find the acceleration produced by a force of 100 N in a mass of 50 kg.

Given Data:

Force = F = 100N
Mass = m = 50Kg

Required:

Acceleration = a =?

Solution:

We know that

$F = ma$

$\frac{F}{m} = a$

$a = \frac{F}{m}$

$a = \frac{100N}{50Kg}$

$a = \frac{100Kgms^{-2}}{50Kg}$

$a = 2ms^{-2}$

3.5 A body has weight 20 N. How much force is required to move it vertically upwards with an acceleration of 2 ms^{-2}?

Given Data:

Weight = w = 20N
Acceleration = a = $2ms^{-2}$

Required:

Force required to move the body vertically upwards = F' =?

Solution:

Force required moving the body vertically upwards is equal to the force F plus its weight w

$$F' = F + w$$
$$F' = ma + w \quad \text{---------- (i)}$$

We know that

$$w = mg$$
$$\frac{w}{g} = m$$
$$m = \frac{w}{g}$$
$$m = \frac{20N}{10ms^{-2}}$$
$$m = \frac{20Kgms^{-2}}{10ms^{-2}}$$
$$m = 2Kg$$

Putting all the values in eq.(i)

$$F' = 2Kg(2ms^{-2}) + 20N$$
$$F' = 4Kgms^{-2} + 20N$$
$$F' = 4N + 20N$$
$$F' = 24N$$

Putting all the values in eq. (i)

$$F' = 2Kg\ (2ms^{-2}) + 20N$$
$$F' = 4Kgms^{-2} + 20N$$
$$F' = 4N + 20N$$
$$F' = 24N$$

3.6 Two masses 52 Kg and 48 Kg are attached to the ends of a string that passes over a frictionless pulley. Find the tension in the string and acceleration in the bodies when both the masses are moving vertically.

Given Data:

$m_1 = 52Kg$
$m_2 = 48Kg$

Required:

Tension = T =?
Acceleration = a =?

Solution:

We know that

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

$$T = \frac{2\times52Kg\times48Kg}{52Kg+48Kg} \times 10ms^{-2}$$

$$T = \frac{4992Kg\times Kg}{100Kg} \times 10ms^{-2}$$

$$T = \frac{4992Kgms^{-2}}{10}$$

$$T = 499.2Kgms^{-2}$$

$$T = 499.2N$$

$$T = 500N \text{ (Approximately)}$$

We know that

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

$$a = \frac{52Kg - 48Kg}{52Kg + 48Kg} \times 10ms^{-2}$$

$$a = \frac{4Kg}{100Kg} \times 10ms^{-2}$$

$$a = 0.4ms^{-2}$$

$$a = \frac{40Kgms^{-2}}{100Kg}$$

$$a = \frac{4ms^{-2}}{10}$$

3.7 Two masses 26 kg and 24 kg are attached to the ends of a string which passes over a frictionless pulley. 26 kg is lying over a smooth horizontal table. 24 N mass is moving vertically downward. Find the tension in the string and the acceleration in the bodies.

Given Data:

$m_1 = 24Kg$
$m_2 = 26Kg$

Required:

Tension = T =?
Acceleration = a =?

Solution:

We know that

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

$$T = \frac{24Kg \times 26Kg}{24Kg + 26Kg} \times 10ms^{-2}$$

$$T = \frac{624Kg \times Kg}{50Kg} \times 10ms^{-2}$$

$$T = 124.8Kgms^{-2}$$

$$T = 124.8N$$

We know that

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

$$a = \frac{24Kg}{24Kg + 26Kg} \times 10ms^{-2}$$

$$a = \frac{240Kgms^{-2}}{50Kg}$$

$$a = 4.8ms^{-2}$$

3.8 How much time is required to change 22Ns momentum by a force of 20 N?

Given Data:

Change in momentum = ΔP = 22Ns

Force = F = 20N

Required:

Time = t = ?

Solution:

We know that

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

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

$$t=\frac{22Ns}{20N}$$

$$t=1.1s$$

3.9 How much is the force of friction between a wooden block of mass 5 kg and the horizontal marble floor? The coefficient of friction between wood and the marble is 0.6.

Given Data:

Mass = m = 5Kg

Coefficient of friction b/w wood and the marble = μ = 0.6

Required:

Force of friction = f = ?

Solution:

We know that

$$f=\mu mg$$

$$f=0.6\times 5Kg\times 10ms^{-2}$$

$$f=30Kgms^{-2}$$

$$f=30N$$

3.10 How much centripetal force is needed to make a body of mass 0.5 kg to move in a circle of radius 50 cm with a speed 3 ms^{-1}?

Given Data:

Mass = m = 0.5Kg

Radius = r = 50cm

$$r = \frac{50}{100} m$$

r = 0.5m

speed = v = $3ms^{-1}$

Required:

Centripetal force = F_c = ?

Solution:

We know that

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

$$F_c = \frac{0.5Kg \times (3ms^{-1})}{0.5m}$$

$$F_c = \frac{0.5Kg \times gm^2s^{-2}}{0.5m}$$

$$F_c = 9Kgms^{-2}$$

$$F_c = 9N \quad (\therefore 1N = 1Kgms^{-2})$$

Turning effect of a force

Q.4.1 Encircle the correct answers from the given choices:

i. Two equal but unlike parallel forces having different line of action produce

(a) a torque (b) a couple (c) equilibrium (d) neutral equilibrium

ii. The number of forces that can be added by head to tail rule are :

(a) 2 (b) 3 (c) 4 (d) any number

iii. The number perpendicular components of a force are:

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

vi. A force of 10 N is making an angle of 30^o with the horizontal component will be:

(a) 4 N (b) 5 N (c) 7 N (d) 8.7 N

Explanation:

It is given that F_x = 10 N, $\theta = 30^o$

$F_X = F\cos\theta$

$10\ N = F \times \cos 30^\circ$

$$F = \frac{10N}{\cos 30^\circ}$$

F = 8.7 N

v. A couple is formed by

(a) Two forces perpendicular to each other
(b) Two like parallel forces
(c) Two equal and opposite forces in the same line
(d) Two equal and opposite forces not in the same line

vii. A body is in equilibrium when its:

(a) Acceleration is uniform
(b) Speed is uniform
(c) Speed and acceleration are uniform
(d) Acceleration is zero

viii. A body is in neutral equilibrium when its centre of gravity:

(a) is at its highest position
(b) Is at its lowest position
(c) Keeps its height if displaced
(d) Is situated at its bottom

Ans:

i. b ii. d iii. b iv. d v. d vi. b vii. c viii. c

Exercise Short Questions

Q.4.2 Define the following: (i) resultant vector (ii) centre of mass (iii) centre of gravity

Ans. (i) Resultant vector:

"The sum of two or more vectors is a single vector which has the same effect as combine effect of all vectors to be added and that single vector is called resultant vector."

Vector should be of same kind to get resultant vector.

(ii) Torque: "The turning effect of a force is called torque."

It is a vector quantity. It is denoted by ' τ '

Formula: Torque = force × moment arm

$$\tau = F \times L$$

SI unit of torque is newton-metre (N m).

(iii) Centre of mass:

"Centre of mass of a system is such point where an applied force causes the system to move without rotation."

(iv)Centre of gravity:

"A point where the whole weight of the body appears to act vertically downward is called centre of gravity of a body." It is denoted by "G".

Q.4.3.(i) Differentiate like and unlike forces.

Ans.

Sr.#	Like parallel forces	Unlike parallel forces
i.	Like parallel forces are the forces that are parallel to each other and have same direction.	Unlike parallel forces are the forces that are parallel but have directions opposite to each other.
ii.	They have different lines of action.	They may have same or different lines of action
iii.	They produce torque.	They produce couple if they have different line of action.
iv.	Example: Weights of every apple in a bag are like parallel forces.	Example: weight of the apple and tension in the string are unlike parallel forces when the string is stretched due to weight of the apple.

(iii)Differentiate between torque and couple.

Sr.#	Torque	Couple
i.	Turning effect of a force is called torque.	A couple is formed by two unlike parallel forces of same magnitude but not along the same line.
ii.	Torque is produced due to a single force.	Couple is produced due to two forces that are equal in magnitude but opposite in direction. Its formula is :
iii.	Torque is calculated by multiplying the size of the force (F) by the perpendicular distance between the axis of rotation and the line of action of the force.	Torque of a couple is calculated by multiplying the size of one of the force (F) by the perpendicular distance between the lines of action of the forces.

(vi)Differentiate between stable and neutral equilibrium.

Sr.#	Stable equilibrium	Neutral equilibrium
i.	A body is said to be in stable equilibrium if after a slight tilt returns to its previous position.	If a body remains its new position when disturbed from its previous position, it is said to be in state of neutral equilibrium.

ii.	In this equilibrium height of centre of gravity can be changes.	In this equilibrium centre of gravity remains at the same height irrespective to its new position.
iii.	In this equilibrium the centre of gravity of the body may or may not act through the base of the body.	In this equilibrium, the centre of gravity of the body always acts through the base of the body.

Q.4.6 When a body is said to be in equilibrium.

Ans. "A body is said to be in equilibrium if no net force acts on it."

A body in equilibrium remains at rest or moves with uniform velocity.

Q.4.8 Why there is a need of second condition for equilibrium if a body satisfies first condition of equilibrium?

Ans. For a body to be in complete equilibrium, both conditions should be satisfied i.e. both linear acceleration and angular acceleration should be zero. In case of couple, two equal but opposite forces act. First condition of equilibrium is satisfied i.e. linear acceleration is zero, yet it may rotate. It has angular acceleration. For angular acceleration to be zero, the net torque acting on it should be zero.

Q.4.9 What is second condition for equilibrium?

Ans. "A body satisfies second condition for equilibrium when the resultant torque acting on it is zero."

Mathematically it is written as

$$\sum \tau = 0$$

Q.4.10 Give an example of a moving body which is in equilibrium.

Ans. "If the body is moving with uniform velocity it is said to be in dynamic equilibrium." So a paratrooper moving down with uniform velocity is said to be in dynamic equilibrium.

Q.4.11 Think of a body which is at rest but not in equilibrium.

Ans. When a ball is thrown upward it becomes at rest at maximum height, at this it is not in equilibrium although it is at rest.

Q.4.12 Why a body cannot be in equilibrium due to single force acting on it?

Ans. According to first condition for equilibrium, a body is in state of equilibrium if the sum of all the forces acting on the body is zero. In case of a single force, the net force cannot be zero. Thus, the body can not be in equilibrium due to single force acting on it.

Q.4.13 Why the height of vehicles is kept as low as possible?

Ans. The height of a vehicle is kept as low as possible so that its center of gravity remains as low as possible. A lower center of gravity keeps the body ore stable.

Important Formula, units and values for Problems

$F_x = F\ COS\theta$, $F_y = F \sin\theta$, $\theta = \tan^{-1}\frac{F_X}{F_Y}$, $\tau = F \times L$

$F = \sqrt{F_X - F_y}$

Torque produced by a couple = F × couple arm

Couple arm is distance between the lines of action of both forces.

SI unit of torque is N m.

$1N = kgms^{-2}$

Problems

4.1 Find the resultant of the following forces:

(i) 10 N along x-axis

(ii) 6 N along y- axis and

(iii) **4N along negative x-axis**

Given Data:

(i) $F_1 = 10N,\ \theta_1 = 0^\circ$

(i) $F_2 = 6N,\ \theta_2 = 90^\circ$

(i) $F_3 = 4N,\ \theta_3 = 180^\circ$

Required:

F=?

θ=?

Solution:

We know that

$$F_{1X} = F\cos\theta_1$$
$$F_{1X} = 10N\cos 0^\circ$$
$$F_{1X} = 10N \times 1$$
$$F_{1X} = 10N$$

$$F_{2X} = F_2\cos\theta_2$$
$$F_{2X} = 6N\cos 90^\circ$$
$$F_{2X} = 6N \times 0$$
$$F_{2X} = 0$$
$$F_{3X} = F_3\cos\theta_3$$
$$F_{3X} = 4N\cos 180^\circ$$
$$F_{3X} = 4N \times (-1)$$
$$F_{3X} = -4N$$

We know that

$$F_X = 6N \times (-1)$$
$$F_X = F_{1X} + F_{2X} + F_{3X}$$
$$F_X = 10N + 0 + (-4N) \quad \Rightarrow F_X = 10N - 4N = 6N$$
$$F_X = 6N$$
$$F_{1y} = F_1\sin\theta_1$$
$$F_{1y} = 10N \times \sin 0^\circ$$
$$F_{1y} = 10N \times 0$$
$$F_{1y} = 0$$
$$F_{2y} = F_2\sin\theta_2$$

$$F_{2y} = 6N \times \sin 90^\circ$$
$$F_{2y} = 6N \times 1$$
$$F_{2y} = 6N$$

$$F_{3y} = F_3 \sin\theta_3$$
$$F_{3y} = 4N \times \sin 180^\circ$$
$$F_{3y} = 4N \times 0$$
$$F_{3y} = 0$$
$$F_y = F_{1y} + F_{2y} + F_{3y}$$
$$F_y = 0 + 6N + 0$$
$$F_y = 6N$$

We know that

$$F = \sqrt{F_x^2 + F_y^2}$$
$$F = \sqrt{(6N)^2 + (6N)^2}$$
$$F = \sqrt{36N^2 + 36N^2}$$
$$F = \sqrt{72N^2}$$
$$F = 8.5N$$

We know that

$$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right)$$
$$\theta = \tan^{-1}\left(\frac{6N}{6N}\right)$$
$$\theta = \tan^{-1}(1)$$
$$\theta = 45^\circ$$

4.2 Find the perpendicular components of a force of 50 N making an angle of 30^o with x-axis.

Given Data:

Force = F = 50N

Angle = $\theta = 30^\circ$

Required:

Perpendiculars components of force $F_x, F_y = ?$

Solution:

$F_x = F\cos\theta$

$F_x = 50N\cos 30^\circ$

$F_x = 10N \times 0.866$

$F_x = 43.3N$

We know that

$F_y = F\sin\theta$

$F_y = 50N \times \sin 30^\circ$

$F_y = 50N \times 0.5$

$F_y = 25N$

4.3 Find the magnitude and direction of a force, if its x-component is 12 N and y-component is 5 N.

Given Data:

x-component of force = F_x = 12N

y-component of force = F_y = 5N

Required:

Magnitude of force = F = ?

Direction of the force = θ=?

Solution:

We know that

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

$F = \sqrt{(12N)^2 + (5N)^2}$

$F = \sqrt{144N^2 + 25N^2}$

$F = \sqrt{169N^2}$

$F = 13N$

We know that

$$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right)$$

$$\theta = \tan^{-1}\left(\frac{5N}{12N}\right)$$

$$\theta = \tan^{-1}\left(\frac{5}{12}\right)$$

$$\theta = 22.6^{\circ}$$

4.4 A force of 100 N is applied perpendicular on a spanner at a distance of 10 cm from a nut. Find the torque produced by the force.

Given Data:

Force = F = 100N

Moment arm = L = 10cm

$$L = \frac{10}{100}m$$

$$L = 0.1m$$

Required:

Torque produced by the force = τ = ?

Solution:

τ = FL

τ = 100N × 0.1m

τ = 10N m

4.5 A force is acting on a body making an angle of 30^o with the horizontal .The horizontal component of force is 20 N. Find the force.

Given Data:

Angle = θ = 30^o

Horizontal component of the force = F_x = 20N

Required:

Force = F = ?

Solution:

We know that

$F_x = F\cos\theta$

$\frac{F_x}{\cos\theta} = F$

$F = \frac{F_x}{\cos\theta}$

$F = \frac{20N}{\cos 30^o}$

$F = \frac{20N}{0.866}$

$F = 23.1N$

4.6 The steering of a car has a radius 16 cm. Find the torque produced by a couple of 50 N.

Given Data:

Radius = r = 16 cm

$r = \frac{16}{100}$ m

r = 0.6 m

Force = F = 50 N

Required:

Torque = τ = ?

Solution

We know that

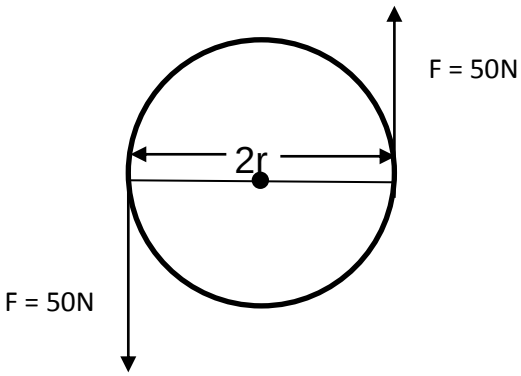
Torque = τ = ?

τ = couple arm × Force

$\tau = 2r \times F$

$\tau = 2 \times 0.16m \times 50N$

$\tau = 16N\,m$



4.7 A picture is hanging by two vertical strings. The tensions in the strings are 3.8 N and 4.4 N. Find the weight of the picture frame.

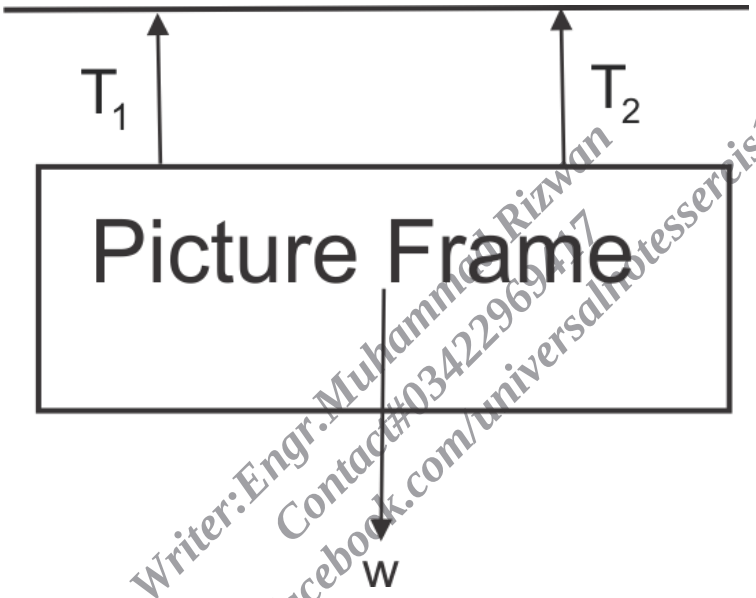
Given Data:

Tension in first string = T_1 = 3.8N
Tension in second string = T_2 = 4.4N

Required:

Weight of the picture frame = w =?

Solution:



According to first condition of equilibrium

$F_y = 0$

$T_1 + T_2 - w = 0$
$T_1 + T_2 = w$
$w = T_1 + T_2$
$w = 3.8N + 4.4N$
$w = 8.2N$

4.8 Two blocks of masses 5 kg and 3 kg are suspended by the two strings as shown. Find the tension in each string.

Given Data:

Tension in first string = T_1 = 3.8N
Tension in second string = T_2 = 4.4N

Required:

Weight of the picture frame = w =?

Solution:

According to first condition of equilibrium

$F_y = 0$

$T_1 + T_2 - w = 0$
$T_1 + T_2 = w$
$w = T_1 + T_2$
$w = 3.8N + 4.4N$
$w = 8.2N$

4.8 Given Data:

Mass of first block = $m_1 = 5kg$
Mass of second block = $m_2 = 3kg$

Required:

Tension in 1st string = T_1 =?
Tension in 2nd string = T_2 =?

Solution:

Tension in 1st string is equal to the weights of both blocks, so

$T_1 = w_1 + w_2$
$T = m_1g + m_2g$

$T_1 = 5kg \times 10ms^{-2} + 3kg \times 10ms^{-1}$

$T_1 = 50kgms^{-2} + 30kgms^{-1}$

$T_1 = 80kgms^{-2}$

$T_1 = 80N$ ($\because 1N = 1kgms^{-2}$)

Tension in 2nd string is equal to the weight of 2nd block, so

$T_2 = w_2$
$T_2 = 3kg \times 10ms^{-2}$
$T_2 = 30kgms^{-2}$
$T_2 = 30N$ ($\because 1N = 1kgms^{-2}$)

4.9 A nut has been tightened by a force of 200 N using 10 cm long spanner. What length of a spanner is required to loosen the same nut with 150 N force?

Given Data:

Force for tightening the nut = F_1 = 200N
Moment arm = L_1 = 10cm

$$L_1 = \frac{10}{100}\text{m}$$
$$L_1 = 0.1\,\text{m}$$

Force for losing the nut = F_2 = 150N

Required:

Length of spanner = L_2 =?

Solution:

We know that

$\tau = F_1L_1$ .....(i)
$\tau = F_2L_2$ .....(ii)
Comparing eq (i) and (ii)
$F_1L_1 = F_2L_2$

$$\frac{F_1L_1}{F_2} = L_2$$

$$L_2 = \frac{F_1L_1}{F_2}$$

$$L_2 = \frac{200\text{N} \times 0.1\text{m}}{150\text{N}}$$

$$L_2 = \frac{2\text{m}}{15}$$

$L_2 = 0.133\text{m}$
$L_2 = 0.133 \times 100\text{cm}$
$L_2 = 13.3\,\text{cm}$

4.10 A block of mass 10 kg is suspended at a distance of 20 cm from the centre of a uniform bar 1m long. What force is required to

balance it at its centre of gravity by applying the force at the other end of the bar?

Given Data:

Mass of the block = m = 10kg
Length of the bar = L = 1m
Moment arm of the weight of block = L_1 = 20cm

$$L_1 = \frac{20}{100}m$$
$$L_1 = 0.2m$$

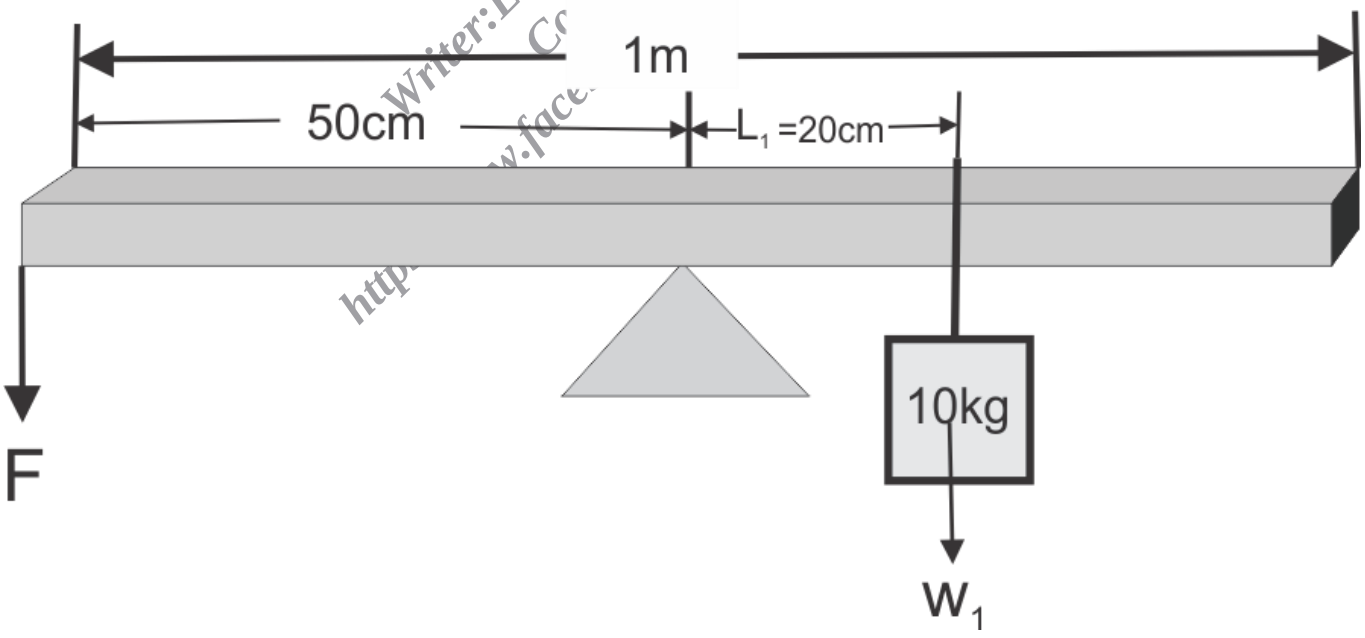
Moment arm of force F = L_2 = 50 cm

$$L_2 = \frac{50}{100}m$$
$$L_2 = 0.5\ m$$

Required:

Force required to balance the bar = F =?

Solution:



According to principle of moments

Clockwise moments = Anticlockwise moments
$w_1 \times L_1 = F \times L_2$

$mg \times L_1 = F \times L_2$

$$\frac{mg \times L_1}{L_2} = F$$

$$F = \frac{mg \times L_1}{L_2}$$

$$F = \frac{10kg \times 10ms^{-2} \times 0.2m}{0.5m}$$

$$F = \frac{20N}{0.5} \qquad (\because 1N = 1kgms^{-2})$$

$$F = 40N$$

Gravitation

Q 5.1 Encircle the correct answer from the given choices:

i. Earth's gravitational force of attraction vanishes at
(a) 6400 km (b) infinity (c) 42300 km (d) 1000 km

Explanation:

We know that

$$F = \frac{Gm_1m_2}{d^2}$$

If $d = \infty$

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

$$F = \frac{G\,m_1\,m_2}{\frac{1}{0}} = \frac{0 \times G\,m_1\,m_2}{1}$$

$$F = \frac{0}{1} = 0$$

So Earth's gravitational force of attraction vanishes at infinity.

ii. Value of g increases with the
(a) Increase in mass of the body

(b) Increase in altitude
(c) Decrease in altitude
(d) None of the above

iii. The value of g at a height one Earth's radius above the surface of the Earth is :

(a) 2g (b) ½ g (c) 1/3 g (d) ¼ g

Explanation:

We know that

$$g_h = \frac{GM_e}{(R+h)^2}$$

If h = R then

$$g_h = \frac{GM_e}{(R+R)^2} = \frac{GM_e}{(2R)^2}$$

$$g_h = \frac{GM_e}{4R^2} = \frac{1}{4} \times \frac{GM_e}{R^2}$$

$$g_h = \frac{1}{4} \times g = \frac{g}{4} \left(\because g = \frac{GM_e}{R^2} \right)$$

vi. The value of g on moon's surface is 1.6 ms^{-2}. What will be the weight of a 100 kg body on the surface of the moon?

(a) 100N (b) 160 N (c) 1000 N (d) 1600 N

Explanation:

It is given that g = 1.6 ms^{-2} , m = 100 kg

w = ?

We know that

w = mg

$$w = 100kg \times 1.6ms^{-2}$$

$$w = 160kgms^{-2}$$

$$w = 160N \left(\because 1N = 1kgms^{-2} \right)$$

vii. The altitude of geostationary orbit in which communication satellites are launched above the surface of the Earth is:

(a) 850 kg (b) 1000 km (c) 6400 km (d) 42,300 km

viii. The orbital speed of a low orbit satellite is :

(a) Zero (b) 8 ms^{-1} (c) 800 ms^{-1} (d) 8000 ms^{-1}

Ans:

i. b ii. c iii. d iv. b v. d vi. d

Exercise Short Questions

Q.5.2 What is meant by the force of gravity?

Ans. "There exists a force due to which every body of the universe attracts every other body is known as the force of gravity."

Q.5.3 Do you attract the Earth or the Earth attracts you? Which one is attracting with a larger force? You or the Earth.

Ans. According to law of gravitation, every object in the universe attracts the other objects. We attract the Earth and Earth attracts us. Since the mass of Earth is very large, it attracts us with a large force.

Q.5.4 What is a field force?

Ans. "When a body attracts other body, whether it is in contact with other or not, then this attracting force is called field force."

The Earth's gravitational force is a field force.

Q.5.5 Why earlier scientists could not guess about the gravitational force?

Ans. Due to very small value of gravitational constant 'G', the gravitational force around us is very small and we do not feel it. This was the reason that the earlier scientists could not guess about the gravitational force.

Q.5.6 How can you say that gravitational force is a field force?

Ans. "When a body attracts other body, whether it is in contact with other or not, then this attracting force is called field force."

Gravitational force is a non-contact force. The gravitational pull of the Earth acting on the body whether the body is in contact with the Earth or not. So, gravitational force is a field force.

Q.5.7 Explain, what is meant by gravitational field strength?

Ans. "In the gravitational field of the Earth, the gravitational force per unit mass is called the gravitational field strength of the Earth."

Near the surface of the Earth, the gravitational field strength is 10 N Kg^{-1}.

Q.5.8 Why law of gravitation is important to us?

Ans. Law of gravitation is important to us because it helps us to calculate the mass of planetary bodies. It helps us to find the gravitational force of other planets in the universe. It is used to understand variation in the value of gravitational acceleration 'g' with altitude. It is used to find the weight of bodies in the universe.

Q.5.9 Explain the law of gravitation.

Ans. Law of gravitation states that:

"Everybody in the universe attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres."

Consider two bodies of masses m_1 and m_2 .The distance between the centers of masses is 'd'. Gravitational force of attraction F is:

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

Q.5.11 Can you determine the mass of our moon? If yes, then what you need to know?

Ans. Yes, the mass of our moon "M_m" can be determined.

Fallowing formula is used to calculate the mass of moon "M_m":

$$M_m = \frac{R^2 g}{G}$$

So we should know the value of gravitational constant 'G', the radius of moon ' R_m' and gravitational acceleration on the surface of Moon 'g_m' .

Q.5.12 Why does the value of g vary from place to place?

Ans. At the surface of the Earth, the value of 'g' is given by the equation:

$$g_h = G\frac{M_e}{(R+h)^2}$$

According to this equation value of 'g' depends upon the height. So the value of 'g' varies from place to place.

Q.5.13 Explain how the value of g varies with altitude.

Ans. Consider a body of mass 'm' at an altitude 'h'. The distance of the body from the centre of the Earth becomes R+h. Value of g with altitude 'h' is :

$$g_h = G \frac{M_e}{(R+h)^2}$$

By increasing altitude 'h', value of R+h increases and g_h decreases. By decreasing altitude 'h', value of R+h decrease and g_h increase.

So the value of 'g' increase with the decrease in altitude and the value of 'g' decreases with the increase in altitude.

Q.5.14 What are artificial satellites?

Ans. "Scientists have sent many objects into space. Some of these objects revolve around the Earth. These are called artificial satellites."

Q.5.15 How Newton's law of gravitation helps in understanding the motion of satellites?

Ans. The satellites are moving around the Earth with centripetal acceleration. This acceleration is caused by the gravitational force between the satellite and the Earth according to Newton's second law of motion.

Q.5.16 On what factors the orbital speed of a satellite depends?

Ans. The orbital speed of a satellite depends upon the height 'h' of the satellite from the surface of the Earth and value of 'g' at that height. The speed of a satellite is given by the following equation:

$$v_o = \sqrt{g_h r_o} \quad \text{where } r_o = R + h$$

Q.5.17 Why communication satellites are stationed at geostationary orbits?

Ans. Communication satellites are stationed at geostationary orbits because in this orbit they move around the Earth with same speed as that of the Earth. So due to these satellites continuous communication at any place on the surface of the Earth can be made.

Important Formula, units and values for Problems

$F = G\frac{m_1\ m_2}{d^2}$, $g = G\frac{M_e}{R^2}$, $g = G\frac{M_e}{(R+h)^2}$

$G = 6.673 \times 10^{-23}\ Nm^2\ kg^{-2}$, $g = 10\ ms^{-2}$

$R = 6.4 \times 10^6 m$, $M_e = 6.0 \times 10^{24}\ Kg$

Problems

5.1 Find the gravitational force of attraction between two spheres each of mass 1000kg. The distance between the centres of the spheres is 0.5 m.

Given Data:

Mass of the two spheres m_1, m_2 = 1000kg
Distance = d = 0.5m

Required:

Gravitational force = F =?

Solution:

We know that

$$F = \frac{Gm_1m_2}{d^2}$$

$$F = \frac{6.673 \times 10^{-11}Nm^2kg^{-2} \times 1000kg \times 1000kg}{(0.5m)^2} \quad (\because G = 6.673 \times 10^{-11}Nm^2kg^{-2})$$

$$F = \frac{6.673 \times 10^{-11}Nm^2kg^{-2} \times 10^6kg^2}{0.25m^2}$$

$$F = \frac{6.673 \times 10^{-11+6}N}{0.25}$$

$$F = 26.7 \times 10^{-5}\ N$$

5.2 The gravitational force between two identical lead spheres kept at 1 m apart is 0.006673 N. Find their masses.

Given Data:

Gravitational Force = F = 0.006673N
Distance = d = 1m

Required:

Masses $m_1 = m_2 = m = ?$

Solution:

We know that

$$F = \frac{Gm_1m_2}{d^2}$$

$$F = \frac{G\,m.m}{d^2}$$

$$F = \frac{G\,m^2}{d^2}$$

$$\frac{Fd^2}{G} = m^2$$

$$m^2 = \frac{Fd^2}{G}$$

$$m = \sqrt{\frac{Fd^2}{G}}$$

$$m = \sqrt{\frac{0.006673N \times (1m)^2}{6.673 \times 10^{-11}Nm^2\ kg^{-2}}}$$

$$m = \sqrt{\frac{0.006673N \times 1m^2}{6.673 \times 10^{-11}\ Nm^2 kg^{-2}}}$$

$$m = \sqrt{\frac{1 \times 10^{-3}}{10^{-11}kg}}$$

$$m = \sqrt{1 \times 10^{-3+11}kg^2}$$

$$m = \sqrt{1 \times 10^{8}kg^2}$$

$$m = \sqrt{1 \times 100000000kg^2}$$

$$m = \sqrt{100000000kg^2}$$

$$m = 10,000kg$$

Hence the mass of each sphere is 10000kg

5.3 Find the acceleration due to gravity on the surface of the Mars. The mass of Mars is 6.42×10^{23} kg and its radius is 3370 km.

Given Data:

Mass of Mars = $M_m = 6.42 \times 10^{23}$kg
Radius of Mars = R_m= 3370km
$R_m = 3370 \times 10^3$m

Required:

Acceleration due to gravity = g_m =?

Solution:

We know that

$$g_m = \frac{GM_m}{R^2 m}$$

$$g_m = \frac{6.673 \times 10^{-11}\ Nm^2kg^{-2} \times 6.42 \times 10^{23}kg}{(3370 \times 10^3\ m)^2}$$

$$g_m = \frac{42.84066 \times 10^{12}\ Nm^2kg^{-1}}{11356900 \times 10^6\ m^2}$$

$$g_m = \frac{42.84066 \times 10^{12-6}\ kgms^{-1}.kg^{-1}}{11356900}$$

$$g_m = \frac{42.84066 \times 10^6\ ms^{-2}}{11356900}$$

$$g_m = \frac{42.84066 \times 1000000\ ms^{-2}}{11356900}$$

$$g_m = \frac{42.84066 ms^{-2}}{11356900}$$

$$g_m = 3.77 ms^{-2}$$

5.4 The acceleration due to gravity on the surface of moon is 1.62 ms^{-2}. The radius of Moon is 1740 km. Find the mass of moon.

Given Data:

Acceleration due to gravity on the surface of Moon = $g_m = 1.62ms^{-2}$
Radius of Moon = R_m = 1740km
$R_m = 1740 \times 10^3$m

Required:

Mass of Moon = M_m =?

Solution:

We know that

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

$$\frac{g_m R_m^2}{G} = M_m$$

$$M_m = \frac{g_m R_m^2}{G}$$

$$M_m = \frac{1.62 ms^{-2} \times (1740 \times 10^3 m)^2}{6.673 \times 10^{-11} Nm^2 kg^{-2}}$$

$$M_m = \frac{1.62 ms^{-2} \times 3027600 \times 10^6 m^2}{6.673 \times 10^{-11} Nm^2 kg^{-2}}$$

$$M_m = \frac{4904712 \times 10^6 m^2}{6.673 \times 10^{-11} kgms^{-2} kg^{-2}}$$

$$M_m = \frac{4904712 \times 10^{6+11}}{6.673 kg^{1-2}}$$

$$M_m = \frac{4904712 \times 10^{17}}{6.673 kg^{-1}}$$

$$M_m = \frac{4904712 \times 10^{17} kg}{6.673}$$

$$M_m = 735008.5 \times 10^{17} kg$$

$$M_m = 7.350085 \times 10^5 \times 10^{17} kg$$

$$M_m = 7.35 \times 10^{5+17} \text{ kg}$$

$$M_m = 7.35 \times 10^{22} \text{ kg}$$

5.5 Calculate the value of g at a height of 3600 km above the surface of the Earth.

Given Data:

Height = h = 3600km

$h = 3600 \times 10^3 m$

h = 3600000m

$R = 6400km = 6400 \times 10^3 m$

$M_e = 6 \times 10^{24} kg$

Required:

The value of g at height h = g_h =?

Solution:

We know that

$$g_h = \frac{GM_e}{(R+h)^2}$$

$$g_h = \frac{6.673 \times 10^{-11} Nm^2kg^{-2} \times 6 \times 10^{24} kg}{(6400 \times 10^3 m + 3600000m)^2}$$

$$g_h = \frac{40.038 \times 10^{-11+24} Nm^2kg^{-2+1}}{(6400 \times 10^3 m + 3600000m)^2}$$

$$g_h = \frac{40.038 \times 10^{13} Nm^2kg^{-1}}{(6400 \times 1000\ m + 3600000m)^2}$$

$$g_h = \frac{40.038 \times 10^{13} Nm^2kg^{-1}}{(6400000m + 3600000m)^2}$$

$$g_h = \frac{40.038 \times 10^{13} kgms^{-2} m^{-2} kg^{-1}}{(10000000m)^2}$$

$$g_h = \frac{40.038 \times 10^{13} ms^{-2}.m^2}{(10^7 m)^2}$$

$$g_h = \frac{40.38 \times 10^{13} ms^{-2}.m^2}{10^{14} m^2}$$

$$g_h = \frac{40.38\ ms^{-2}}{10^{14-13}}$$

$$g_h = \frac{40.38\ ms^{-2}}{10^{14-13}}$$

$$g_h = 4.038 ms^{-2}$$

$$g_h = 4.0 ms^{-2}$$

5.6 Find the value of g due to the Earth at geostationary satellite. The radius of the geostationary orbit is 48700 km.

Given Data:

Radius of geostationary orbit = $r_0 = R + h = 48700km$

$r_0 = R + h = 48700 \times 10^3\ m$

Mass of Earth = $M_e = 6 \times 20^{24} kg$

Required:

Value of g at geostationary orbit = g_h =?

Solution:

We know that

$$g_h = \frac{GM_e}{(R+h)^2}$$

$$g_h = \frac{6.673 \times 10^{-11} Nm^2kg^{-2} \times 6 \times 10^{24} kg}{(48700 \times 10^3 m)^2}$$

$$g_h = \frac{40.038 \times 10^{-11+24} Nm^2kg^{-2+1}}{2371690000 \times 10^6 m^2}$$

$$g_h = \frac{40.038}{2.3769 \times 10^9 \times 10^6}$$

$$g_h = \frac{40.038 \times 10^{13} Nkg^{-1}}{2.3769 \times 10^{15}}$$

$$g_h = \frac{40.038 \times 10^{13} kgms^{-2}kg^{-1}}{2.3769 \times 10^{15-13}}$$

$$g_h = \frac{40.038\, ms^{-2}}{2.3769 \times 10^2}$$

$$g_h = \frac{40.038\, ms^{-2}}{237.69}$$

$$g_h = 0.17 ms^{-2}$$

5.7 The value of g is 4.0 ms^{-2} at a distance of 1000 km from the centre of the Earth. Find the mass of the Earth.

Given Data:

Value of $g = g_h = 4.0 ms^{-2}$

Distance from the center of Earth = R + h = 10000km

$R + h = 10000 \times 10^3 m$

$R + h = 10000 \times 10^3 m$

$= 10^4 \times 10^3 m$

$= 10^{4+3} m$

$R + h = 10^7 m$

Required:

Mass of Earth = M_e =?

Solution:

We know that

$$g_h = \frac{GM_e}{(R+h)^2}$$

$$\frac{g_h(R+h)^2}{G} = M_e$$

$$M_e = \frac{g_h(R+h)^2}{G}$$

$$= \frac{4ms^{-2}(10^7m)^2}{6.673 \times 10^{-11}Nm^2kg^{-2}}$$

$$= \frac{4ms^{-2}10^{14}m^2}{6.673 \times 10^{-11}Nm^2kg^{-2}}$$

$$= \frac{4 \times 10^{14+11}\ ms^{-2}}{6.673\ Nms^{-2}\ kg^{-2}}$$

$$= \frac{4 \times 10^{25}}{6.673 kg^{1-2}}$$

$$= \frac{4 \times 10^{25}}{6.673\ kg^{-1}}$$

$$= 0.599 \times 10^{25}\ kg$$

$$= 5.99 \times 10^{-1} \times 10^{25}\ kg$$

$$= 5.99 \times 10^{25-1}\ kg$$

$$M_e = 5.99 \times 10^{24}\ kg$$

5.8 At what altitude the value of g would become one forth than on the surface of the Earth?

Given Data:

$$g_h = \frac{g}{4}$$

Required:

Altitude = h =?

Solution:

$$g_h = \frac{g}{4} \qquad \text{…….(1)}$$

We know that

$$g_h = \frac{GM_e}{(R+h)^2}$$

$$g=\frac{GM_e}{R^2}$$

Eq (1) becomes

$$\frac{GM_e}{(R+h)^2}=\frac{\frac{GM_e}{R^2}}{4}$$

$$\frac{GM_e}{(R+h)^2}=\frac{GM_e}{4R^2}$$

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

$$4R^2=(R+h)^2$$

Taking square root on both side

$$\sqrt{4R^2}=\sqrt{(R+h)^2}$$

$$2R=R+h$$

$$2R-R=h$$

$$R=h$$

$$h=R$$

Thus Altitude = One Earth's radius

5.9 A polar satellite is launched above Earth. Find its orbital speed.

Given Data:

Altitude = h = 850km

$h = 850 \times 10^3 m$

$M_e = 6 \times 10^{24} kg$

R = 6400km

$R = 6400 \times 10^3 m$

Required:

Orbital speed = v_0 =?

Solution:

We know that

$$g_h = \frac{GM_e}{(R+h)^2}$$

$$= \frac{6.673 \times 10^{-11}\ Nm^2\ kg^{-2} \times 6 \times 10^{24} kg}{(6400 \times 10^3 m + 850 \times 10^3 m\ )}$$

$$= \frac{40.038 \times 10^{-11+24}\ Nm^2\ kg^{-2+1}}{(6400 \times 1000m + 850 \times 1000m\ )}$$

$$= \frac{40.038 \times 10^{13}\ Nm^2\ kg^{-1}}{(6400000m + 850000m)^2}$$

$$g_h = \frac{40.038 \times 10^{13}\ Nm^2\ kg^{-1}}{(7250000m)^2}$$

$$g_h = \frac{40.038 \times 10^{13}\ Nm^2 kg^{-1}}{(5.25625 \times 10^{13} m^2}$$

$$g_h = \frac{40.038 Nkg^{-1}}{5.25625}$$

$g_h = 7.62 kgms^{-2}kg^{-1}$ $(\because 1N = 1kgms^{-2})$

$g_h = 7.62 ms^{-2}$

We know that

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

$$v_0 = \sqrt{7.62 ms^{-1}(6400 \times 10^3 m + 850 \times 10^3 m)}$$

$$v_0 = \sqrt{7.62 ms^{-2}(6400000m + 8500000m)}$$

$$v_0 = \sqrt{7.62 ms^{-2} \times 7250000m}$$

$$v_0 = \sqrt{55245000 m^2 s^{-2}}$$

$v_0 = 7431 ms^{-1}$

5.10 A communication satellite is launched at 42000 km above Earth. Find its orbital speed.

Given Data:

Altitude = h = 42000km

$h = 42000 \times 10^3$ m

$M_e = 6 \times 10^{24}$kg

R = 6400km

$R = 6400 \times 10^3$m

Required:

Orbital speed = v_0 =?

Solution:

We know that

$$g_h = \frac{GM_e}{(R+h)^2}$$

$$g_h = \frac{6.673 \times 10^{-11} Nm^2kg^{-2} \times 6 \times 10^{24} kg}{(6400 \times 10^3 m + 42000 \times 10^3 m)^2}$$

$$= \frac{40.038 \times 10^{-11+24} Nm^2kg^{-2+1}}{(6400 \times 1000m + 42000 \times 1000m)}$$

$$= \frac{40.038 \times 10^{13} Nm^2kg^{-1}}{(6400000m + 42000000m)^2}$$

$$= \frac{40.038 \times 10^{13} Nm^2kg^{-1}}{(48400000m)^2}$$

$$= \frac{40.038 \times 10^{13} kgms^{-2}m^2kg^{-1}}{2.34256 \times 10^{15} m^2}$$

$$\frac{40.038\ ms^{-2}}{2.34256 \times 10^{15-13}}$$

$$= \sqrt{g_h(R+h)}$$

$$\sqrt{0.17ms^{-2}(6400 \times 10^3 m + 42000 \times 10^3 m)}$$

$$= \frac{40.038\ ms^{-2}}{2.34256 \times 10^2}$$

$$= \frac{40.038\ ms^{-2}}{2.34256 \times 100}$$

$$= \frac{40.038\ ms^{-2}}{234.256}$$

$$g_h = 0.17ms^{-2}$$

We know that

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

$$= \sqrt{0.17ms^{-2}(6400 \times 10^3 m + 42000 \times 10^3 m)}$$

$$= \sqrt{0.17ms^{-2}(6400 \times 1000m + 42000 \times 1000m)}$$

$$= \sqrt{0.17ms^{-2}(6400000m + 42000000m)}$$

$$= \sqrt{0.17ms^{-2}(48400000m)}$$

$$= \sqrt{8276400m^2s^{-2}}$$

$$v_0 = 2876ms^{-1}$$

6 Work and Energy

6.1 Encircle the correct answer from the given choices

i. The work done will be zero when the angle between the force and the distance is

(a) 45^o (b) 60^o (c) 90^o (d) 180^o

Explanation:

Work is said to be done when body covers displacement in the direction of force i.e. $\theta = 0^\circ$. We know that $W=FS\cos\theta$ if $\theta = 90^\circ$ then

$W=FS\cos 90^\circ = FS\times 0 = 0$.

So the work done will be zero when the angle between the force and distance is 90^o.

ii. If the direction of motion of the force is perpendicular to the direction of motion of the body then work done will be

(a) Maximum (b) Minimum (c) zero (d) None of the above

Explanation:

See MCQ's (i) explanation.

iii. If the velocity of a body becomes double, then its kinetic energy will

(a) remains the same
(b) become double
(c) becomes four times
(d) becomes half

Explanation:

We know that

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

If $v' = 2v$ then $K.E' = \frac{1}{2}m(2v)^2$

$K.E.' = \frac{1}{2}m \times 4v^2 = 4 \times \frac{1}{2}mv^2$

K.E.' = 4 K.E

If we double the velocity of a body, then its K.E. will become four times.

iv. The work done in lifting a brick of mass 2 kg through a height of 5m above ground will be

(a) 2.5 J (b) 10 J (c) 50 J (d) 100 J

Explanation:

It is given that m=2 kg, h = 5m

Work dine in lifting a brick = mgh

$= 2\ kg \times 10\ ms^{-2} \times 5m$

$= 100\ kg\ ms^{-2} \times m$

$= 100\ N\ m \quad (\because 1N = 1kgms^{-2})$

$= 100\ J \quad (\because 1J = 1Nm)$

v. The kinetic energy of a body of mass 2 kg is 25 J. Its speed is

(a) 5 ms^{-1} (b) 12.5 ms^{-1} (c) 25 ms^{-1} (d) 50 ms^{-1}

Explanation:

It is given that m = 2kg, K.E = 25 J

v =?

We know that $K.E = \frac{1}{2}mv^2$

$25J = \frac{1}{2} \times 2kg \times v^2$

$$25\text{Nm} = \text{kgv}^2$$
$$25\text{kgms}^{-2}\text{m} = \text{kgv}^2$$
$$25\text{m}^2\text{s}^{-2} = \text{v}^2$$
$$\text{v}^2 = 25\text{m}^2\text{s}^{-2}$$
$$\sqrt{\text{v}^2} = \sqrt{25\text{m}^2\text{s}^{-2}}$$
$$\text{v} = 5\text{ms}^{-1}$$

vi. Which one of the following converts light energy into electrical energy?
(a) electric bulb (b) electric generator (c) Photocell (d) Electric Cell

vii. When a body is lifted through a height h, the work done on it appears in the form of its
(a) Kinetic energy
(b) potential energy
(c) elastic potential energy
(d) geothermal energy

viii. The energy stored in coal is
(a) heat energy
(b) kinetic energy
(c) chemical energy
(d) nuclear energy

ix. The energy stored in a dam is
(a) electric energy
(b) potential energy
(c) kinetic energy
(d) thermal energy

x. In Einstein's mass-energy equation , c is the
(a) speed of sound
(b) speed of light
(c) speed of electron
(d) speed of Earth

xi. Rate of doing work is called
(a) energy (b) torque (c) power (d) momentum

Ans:

i. c ii. c iii. c iv. d v. a vi. c vii. b viii. a ix. b x. b xi. c

Exercise Short Questions

Q.6.2 Define work. What is its SI unit?

Ans. "Work is done when a force acting on a body displaces it in the direction of a force." It is a scalar quantity. Its SI unit is joule (J). Its formula is:

$$\text{Work done} = \text{Force} \times \text{displacement}$$

$$W = FS$$

Q.6.3 When does a force do work? Explain.

Ans. Work is said to be done when a force acting on a body displaces it in the direction of the force. So a force does work

Q.6.4 why do we need energy?

Ans. We need energy to perform various activities of our everyday life. Energy is an essential part of our daily life. We use energy to heat and cool our homes .We use energy for lights and appliances. Energy makes our vehicles go , planes fly, boats sail and machines run.

Q.6.5 Define energy, give two types of mechanical energy.

Ans. "A body possesses energy if it is capable to do work." Its SI unit is joule (J).

Mechanical energy possessed by a body is of two types: kinetic energy and potential energy.

Q.6.8 Why fossil fuels are called non- renewable form of energy?

Ans. "The sources of energy which will run out and cannot be used again and again are called non- renewable sources of energy."

The fossil fuels are used one time to get energy. They cannot be used again and again. So fossil fuels are called non-renewable form of energy.

Q.6.9 Which form of energy is most preferred and why?

Ans. Solar energy and energy from water power are very cheap and does not create much environmental pollution. Therefore, these forms of energy are most preferred.

Q.6.10 How is energy converted from one form to another? Explain

Ans. " Energy cannot be destroyed but it can be converted from one form to another and the total amount of energy remains constant at any time ."

For example heat energy is converted into mechanical energy and electrical energy can be converted into mechanical energy and electrical energy can be converted into light and heat energy.

Q.6.11 Name the five devices that convert electrical energy into mechanical energy.

Ans. Following are the five devices that convert electrical energy into mechanical energy:

(1) Electric fan
(2) Electric motor
(3) Grinding machine
(4) Washing machine
(5) Drill machine

Q.6.12 Name a device that converts mechanical energy into electrical energy.

Ans. Electrical generator converts mechanical energy into electrical energy.

Q.6.13 what is meant by the efficiency of a system?

"Efficiency of a system is the ratio of required form of energy obtained from a system as output to the total energy given it as input."

$$\text{Efficiency} = \frac{\text{required form of output}}{\text{total input energy}}$$

$$\%\text{Efficiency} = \frac{\text{required form of output}}{\text{total input energy}} \times 100$$

Q.6.14 How can you find the efficiency of a system?

Ans. Efficiency of the system can be founded by following formula:

$$\text{Efficiency} = \frac{\text{required form of output}}{\text{total input energy}}$$

Q.6.15 What is meant by term power?

Ans. "Power is defined as the rate of doing work."

It is a scalar quantity. Its SI unit is watt (W). Its formula is:

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

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

Q.6.16 Define watt.

Ans. "Power of a body is one watt if it does work at the rate of 1 joule per second ($1Js^{-1}$)".

Important Formula, units and values for Problems

$W = FS$, $P.E = mgh$, $K.E = \frac{1}{2}mv^2$, $P = \frac{W}{t}$

K.E. when stone hits the ground = P.E. at its maximum height

$\%\ \text{Efficiency} = \frac{\text{output}}{\text{input}}$

$1N = 1\ kg\ ms^{-2}$, $1J = 1N\ m$, $1W = 1Js^{-1}$

SI unit of work (W) is joule (J).

SI unit of power (P) is watt (W).

Efficiency has no unit because it is ratio between same quantities.

Problems

6.1 A man has pulled a cart through 35 m applying a force of 300 N. Find the work done by the man.

Given Data:

Distance = S = 35 m
Force = 300 N

Required:

Work done = W =?

Solution:

We must know that

W = FS
W = 300N x 35m
W = 10500Nm

6.2 A block weighing 20 N is lifted 6 m vertically upward. Calculate the potential energy stored in it.

Given Data:

Weight of the block = w = 20N
Height = h = 6m

Required:

Potential Energy = P.E =?

Solution:

We must know that

P.E = mgh ……(i)

We know that

$w = mgh$

$\frac{w}{g} = m$

$m = \frac{w}{g}$

$m = \frac{20N}{10ms^{-2}}$

$m = \frac{20kgms^{-2}}{10ms^{-2}}$

$m = 2kg$

Putting all the values in eq (i)

P.E = mgh

P.E = 2kg x $10ms^{-2}$ x 6m

P.E = 120 $kgms^{-2}$ m

P.E = 120Nm ($\because 1N = 1kgms^{-2}$)

P.E = 120J

6.3 A car weighing 12 KN has speed of 20 ms^{-1}. Find its kinetic energy.

Given Data:

Weight of the car = w = 12kn

w = 12 x 10^3 N ($\because 1k = 10^3$)

w = 12 x 1000N

w = 12000N

Speed of the car = v = $20ms^{-1}$

Required:

Kinetic Energy = K.E = ?

Solution:

We know that

$$K.E=\frac{1}{2}mv^2 \quad .....(i)$$

We know that

$w = mg$

$$\frac{w}{g}=m$$

$$\frac{12000N}{10ms^{-2}} = m$$

$$1200kg = m$$

$$m = 1200kg$$

Putting all the values in eq (i)

$$K.E=\frac{1}{2}mv^2 \quad .....(i)$$

$$K.E=\frac{1}{2}1200kg\times(20ms^{-1})^2$$

$$K.E = 600kg\times 400m^2s^{-2}$$

$$K.E = 600kgm^2s^{-2}$$

$$K.E = 600kgms^{-2}m$$

$$K.E = 600Nm$$

$$K.E = 600J$$

6.4 A 500 g stone is thrown up with a velocity of 15 ms^{-1}. Find its

(i) P.E. at its maximum height

(ii) K.E. when it hits the ground

Given Data:

Mass of the stone = m = 500g

$$m=\frac{500}{1000}kg$$

$$m=0.5kg$$

$$velocity=v=15ms^{-1}$$

Required:

(i) P.E at its maximum height = ?
K.E when it's the ground = ?

Solution:

P.E at its maximum height = K.E when it hits the ground

P.E at its maximum height = $K.E = \frac{1}{2}mv^2$

$K.E = \frac{1}{2}0.5 \times 225 m^2 s^{-2}$

P.E at its maximum height = $K.E = \frac{112.5 kg m^2 s^{-2}}{2}$

$K.E = 56.25 kg m s^{-2} m$

$K.E = 56.25 Nm$

P.E at its maximum height = 56.25J

(ii) We know that

K.E when it hits the ground = P.E at its maximum height
K.E when it hits the ground = 56.25J

6.5 On reaching the top of a slope 6 m high from its bottom, a cyclist has a speed of 1.5 ms^{-1}. Find the kinetic energy and the potential energy of the cyclist. The mass of the cyclist and his bicycle is 40 kg.

Given Data:

Height = h = 6m
Speed = v = $15 ms^{-1}$
Mass of the ? = m = 40kg

Required:

K.E = ?
P.E = ?

Solution:

We know that

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

$K.E = \frac{1}{2}\times 40kg \times (1.5ms^{-1})^2$

$K.E=20kg \times 2.25m^2s^{-2}$

$K.E=45kgm^2s^{-2}$

$K.E=45kgms^{-2}m$

$K.E=45Nm \quad (\because 1N=1kgms^{-2})$

$K.E=45J \quad (\because 1J=1Nm)$

We know that

$P.E = mgh$

$P.E = 40kg \times 10ms^{-2} \times 6m$

$P.E = 2400kgms^{-2}m$

$P.E = 2400Nm \quad (\because 1N=1kgms^{-2})$

$P.E=2400J$

6.6 A motor boat moves at a steady speed of 4 ms^{-1}. Water resistance acting on it is 4000 N. Calculate the power of its engine.

Given Data:

Speed of motor boat = $v = 4ms^{-1}$

Water resistance of force = F = 4000N

Required:

Power = P =?

Solution:

We know that

$P = Fv$

$P = 4000N \times 4ms^{-1}$

$P = 16000Nms^{-1}$

$P = 16000kgms^{-2}ms^{-1}$

$P = 16000kgm^2s^{-2}s^{-1}$

$P = 16000kgms^{-2}m.s^{-1}$

$P = 16000Nms^{-1} \quad (\because 1N=1kgms^{-2})$

$P = 16000 Js^{-1}$ $(\because 1J=1Nm)$

$P = 16000 W$ $(\because 1W=1Js^{-1})$

$P = 16 \times 1000\ W$

$P = 16 \times 10^3\ W$

$P = 16\ KW$ $(\because 1K=10^3)$

6.7 A man pulls a block with a force of 300 N through 50 m in 60 s. Find the power used by him to pull the block.

Given Data:

Force = F = 300N
Distance = S = 50m
Time = t = 60s

Required:

Power = P =?

Solution:

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

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

$$P = \frac{300N \times 50m}{60s}$$

$$P = \frac{15000Nm}{60s}$$

$$P = \frac{1500J}{6s} \quad (\because 1J = 1Nm)$$

$$P = 250 Js^{-1}$$

$$P = 250W \quad (\because 1W = 1Js^{-1})$$

6.8 A 50 Kg man moved 25 steps up in 20 seconds. Find his power, if each step is 16 cm high.

Given Data:

Mass = m = 50kg
No. of steps = n = 25

Time = t = 20s

Height of each step = 16cm

$$= \frac{16}{100}\text{m}$$

$$= 0.16\text{m}$$

Required:

Power = P =?

Solution:

We know that

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

$$P = \frac{P.E}{t}$$

$$P = \frac{mgh}{t} \quad .....(i)$$

Height = h = No. of steps x Height of each step

h = 25 x 0.6m

h = 4m

Putting all the values in eq (i)

$$P = \frac{50\text{kg} \times 10\text{ms}^{-2} \times 4\text{m}}{20\text{s}}$$

$$P = \frac{2000\text{kgms}^{-2}\text{m}}{20\text{s}}$$

$$P = \frac{2000\text{Nm}}{20\text{s}} \quad (\because 1\text{N} = 1\text{kgms}^{-2})$$

$$P = 1000\,\text{Js}^{-1} \quad (\because 1\text{J} = 1\text{Nm})$$

$$P = 1000\,\text{W} \quad (\because 1\text{W} = 1\text{Js}^{-1})$$

6.9 Calculate the power of a pump which can lift 200 kg of water through a height of 6 m in 10 seconds.

Given Data:

Mass of the water = m = 200kg

Height = h = 6m

Time = t = 10s

Required:

Power = P =?

Solution:

We must know that

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

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

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

$$P=\frac{200kg \times 10ms^{-2} \times 6m}{10s}$$

$$P=\frac{12000\ kgms^{-2}m}{10s}$$

$$P=\frac{12000Nm}{10s} \qquad (\because 1N=1kgms^{-2})$$

$$P=\frac{1200J}{s} \qquad (\because 1J=1Nm)$$

$$P=1200Js^{-1}$$

$$P=1200\,W \qquad (\because 1W=1Js^{-1})$$

6.10 An electric motor of 1hp is used to run water pump. The water pump takes 10 minutes to fill an overhead tank. The tank has a capacity of 800 litres and height of 15 m. Find the actual work done by the electric motor to fill the tank. Also find the efficiency of the system.

Given Data:

Power of the electric water = P = 1hp

$$P = 746W \qquad (\because 1hp=746\,W)$$

Time = t = 10min
t = 10 x 60s
t = 600s
Height = h = 15m
Capacity of tank = 800 liters

Required:

Actual work done by the electronic motor = W =?
Efficiency of the system = η =?

Solution:

We know that

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

$$Pt = W$$

$$W = Pt$$

$$W = 746W \times 600s$$

$$W = 44760Ws$$

$$W = 44760\frac{J}{s} \times s \qquad (\because 1W = \frac{J}{s})$$

$$W = 447600J$$

$$Input = W$$

$$Input = 447600J$$

We know that

Mass of 1 liter water of water = 1kg
Mass 800 liters of water = m = 800kg

Output = mgh
= 800kg x $10ms^{-2}$ x 15m
= $120000kgms^{-2}m$
= 120000Nm $\qquad (\because 1N = 1kgms^{-2})$

Output = 120000J $\qquad (\because 1J = 1Nm)$

We know that

$$\%\eta = \frac{ouput}{input} \times 100$$

$$\%\eta = \frac{120000J}{447600J} \times 100$$

$$\%\eta = \frac{12000000}{447600}$$

$$\%\eta = \frac{120000}{4476}$$

$$\%\eta = 26.8\%$$

Properties of Matters

7.1 Encircle the correct answer from the given choices

i. In which of the following state of molecules do not leave their positions?

(a) solid (b) liquid (c) gas (d) plasma

ii. Which of the substance is lightest one?

(a) copper (b) mercury (c) aluminum (d) lead

iii. SI unit of pressure is pascal, which is equal to:

(a) 10^4 Nm^{-2} (b) 1 Nm^{-2} (c) 10^2 Nm^{-2} (d) 10^3 Nm^{-2}

vi. What should be the approximate length of a glass tube to construct a water barometer?

(a) 0.5 m (b) 1 m (c) 2.5 m (d) 11 m

v. According to Archimedes, upthrust is equal to:

(a) weight of displaced liquid

(b) volume of displaced liquid

(c) mass of displaced liquid

(d) none of these

vi. The density of a substance can be found with the help of :

(a) Pascal's law

(b) Hook's law

(c) Archimedes principle

(d) Principle of floatation

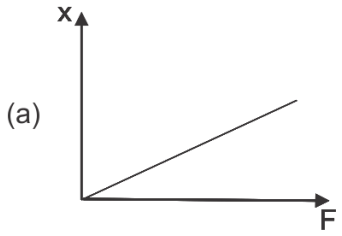
vii. According to Hook's law

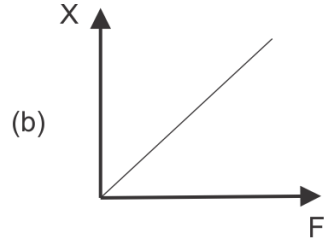
(a) stress× strain = constant

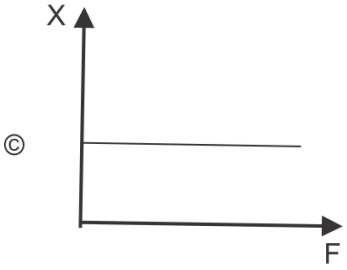
(b) stress/strain = constant

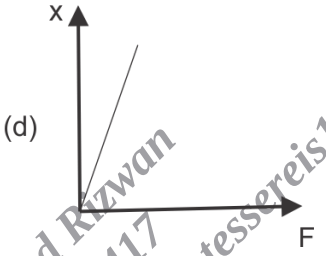
(d) stress = strain

The following force-extension graphs of a spring are drawn on the same scale. Answer the questions below from (viii) to (x).









viii. Which graph does not obey Hook's law?

(a) (b) (c) (d)

ix. Which graph gives the smallest value of spring constant?

(a) (b) (c) (d)

Explanation:

$$\text{Constant} = \frac{\text{Force}}{\text{Extension}}$$

In option (d) Force has smallest value and extension has largest value than Other graphs. So in option (d) spring constant has smallest value.

x. Which graph gives the largest value of spring constant?

(a) (b) (c) (d)

Explanation:

$$\text{Constant} = \frac{\text{Force}}{\text{Extension}}$$

In option (a) Force has largest value and extension has smallest value than

Other graphs. So in option (a) spring constant has largest value.

Ans:

i. a ii. c iii. b iv. d v. a vi. c vii. b viii. c ix. d x. a

Exercise Short Questions

Q.7.2 How kinetic molecular model of matter helpful in differentiating various states of matter?

Ans. Kinetic molecular model helps in understanding the properties of matter in simplified way. It is due to kinetic molecular model of matter that we come to know about various characteristics of three states of matter such as solids, liquids and gases.

Q.7.3 Does there exist a fourth state of matter? What is that?

Ans. Yes, there exists a fourth state of matter which is plasma.

Plasma: "At very high temperature, the collision between atoms and molecules tear off their electrons. Thus, atoms become positive ions. This ionic state of matter is called plasma."

Q.4 What is meant by density? What is its SI unit?

Ans. "Density of a substance is defined as its mass per unit volume." It is a scalar quantity. Its SI unit is Kgm^{-3}.

Its formula is:

$$\text{Density} = \frac{\text{Mass}}{Volume}$$

$$\text{Density} = \frac{\text{m}}{V}$$

Q.7.5 Can we use hydrometer to measure the density of milk?

Ans. Yes, we can use hydrometer to measure the density of milk. But for this purpose, a special kind of hydrometer known as locometer is used.

Q.7.6 Define the term pressure.

Ans. "The force acting normally per unit area on the surface of a body is called pressure." It is denoted by 'P'. It is a scalar quantity. Its SI unit is Nm^{-2}.

Its formula is:

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

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

Q.7.7 Show that atmosphere exerts pressure.

Ans. In atmosphere of the Earth, there are gases, water vapours and dust particles. All of these consist of material particles. Due to the force of gravity acting on these particles the object inside the atmosphere experience pressure in all around equally.

Q.7.8 It is easy to remove air from a balloon but it is very difficult to move air from a glass bottle. Why?

Ans. The air inside balloon is compressed air. Pressure inside the balloon is greater than the atmospheric pressure. So it is easy to remove air from a balloon. But air inside a glass bottle is already at atmospheric pressure. So it is very difficult to remove air from a glass bottle.

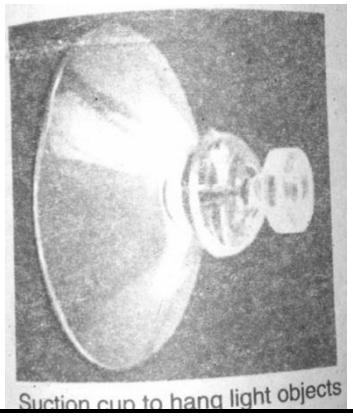
Q.7.9 What is barometer?

Ans. "The instrument that measures atmospheric pressure is called barometer."

Q.7.10 Why water is not suitable to be used in a barometer.

Ans. Water is not suitable to be used in a barometer because it has low density. A glass tube more than 10m is required to make a water barometer. Water is transparent which would make observing reading quite difficult. Freezing point of water is not very low, so water freezes and breaks the glass tube. Boiling point of water is not very high, so water evaporates easily.

Q.7.11 What makes a sucker pressed on a smooth wall to stick it?



Suction cup to hang light objects

Ans. The sucker is disk shaped. When pressed against a smooth surface, the air is forced from beneath the sucker. The rubber makes an air tight seal and the air pressure outside is greater than the air pressure beneath the sucker, thus forcing the sucker to stick it on a smooth wall.

Q.7.12 Why does the atmosphere pressure vary with height?

Ans. Atmospheric pressure is due to the number of molecules hitting you. As you go up, there are less molecules hitting you i.e. atmospheric pressure decreases due to decrease in density of air. Thus atmospheric pressure varies with height.

Q.7.13 What does it mean when the atmospheric pressure at a place fall suddenly?

Ans. The changes in atmospheric pressure at a certain place indicate the expected changes in the weather condition of that place. A sudden fall in atmospheric pressure often followed by a storm, rain and typhoon to occur in few hours time.

Q.7.14 What changes are expected in weather if the barometer reading shows a sudden increase?

Ans. Sudden increase in the barometer reading means that there is rapid increase in atmospheric pressure. The changes in atmospheric pressure at a certain place indicate the expected changes in the weather conditions of that place. A rapid increase in atmospheric pressure means that it will soon followed by a decrease in the atmospheric pressure indicating poor condition ahead.

Q.7.15 State Pascal's law.

Ans. Pascal's law states that:

"Pressure applied at any point of a liquid enclosed in a container, is transmitted without loss to all other parts of the liquid."

In general, this law holds good for fluids both for liquids as well as gases.

Q.7.17 What is meant by elasticity?

Ans. "The property of a body to restore its original size and shape as the deforming force ceases to act is called elasticity."

Q.7.18 State Archimedes principle.

Ans. Archimedes principle states:

"When an object is totally or partially immersed in a liquid, an upthrust act on it equal to the weight of the liquid it displaces."

Q.7.19 What is upthrust? Explain the principle of floatation.

Ans. Upthrust: "An upward force exerted by a fluid that opposes the weight of an immersed object is called upthrust."

The principle of floatation:

The principal of floatation states:

"A floating object displaces a fluid having weight equal to the weight of the object."

When an object floats in a fluid, the upthrust acting on it is equal to the weight of the object. In case of floating object, the object may be partially immersed. The upthrust is always equal to the weight of the fluid displaced by the object. This is the principle of floatation.

Q.7.20 Explain how a submarine moves up the water surface and down into water.

Ans. When a submarine is not filled with sea water, its weight is less than upthrust acting on it. So it floats on the surface of sea water. But when it filled with water, then its weight is greater than the upthrust acting on it. So it sinks into water.

Q.7.21 Why does a piece of stone sink in water but a ship with huge weight floats?

Ans. A piece of stone sinks in water because the weight of the stone is greater than the weight of an equal volume of water. On the other hand a ship with a huge weight floats over water because the weight of an equal volume of water is greater than the weight of the ship.

Q.7.22 What is Hook's law? What is meant by elastic limit?

Ans. Hook's law states that:

"The strain produced in a body by the stress applied to it is directly proportional to the stress within the elastic limit of the body.

$$\text{Thus} \quad \text{stress} \propto \text{strain}$$

$$\text{Stress} = \text{constant} \times \text{strain}$$

$$\frac{\text{stress}}{\text{strain}} = \text{constant}$$

Elastic Limit: "It is a limit within which a body recovers its original length, volume or shape after the deforming force is removed." When a stress crosses this limit, a

body is permanently deformed and is unable to restore its original state after the stress is removed.

Important Formula, units and values for Problems

Volume = length × width × height

Density= $\frac{\text{Mass}}{\text{Volume}}$

Volume= $\frac{\text{Mass}}{\text{Density}}$

$P = \frac{F}{A}$, $A=\pi r^2$, $A = \pi d^2/4$

$F_2 = F_1 \times \frac{A}{a}$, $Y = \frac{FL}{A\Delta L}$

SI unit for volume (V) is m^3

SI unit for density is Nm^{-2}

SI unit for Area is m^2

SI unit for force is newton (N)

SI unit for Young's modulus is Nm^{-2}.

We change unit cm to m by dividing value on 100.

We change mm to m by dividing value on 1000.

1 milli (m) = 10^{-3}

1 centi (c) = 10^{-2}

Problems

7.1 A wooden block measuring 40 cm × 10 cm × 5 cm has a mass 850 g. Find the density of wood.

Given Data:

Volume of wooden block = V = 40cm × 10cm × 5cm

$$V = \frac{40}{100}m + \frac{10}{100}m + \frac{5}{100}m$$

$$V = \frac{2000}{1000000}m^3$$

$$V = 0.002m^3$$

Mass of the block = m = 850g

$$m = \frac{850}{1000}kg$$

$$m = 0.85kg$$

Required:

Density = ρ =?

Solution:

We know that

$$\rho = \frac{m}{V}$$

$$\rho = \frac{085kg}{0.002m^3}$$

$$\rho = 425kgm^{-3}$$

7.2 How much would be the volume of ice formed by freezing 1 litre of water?

Given Data:

Volume of water = 1litre

Required:

Volume of ice =?

Solution:

When we freeze the water its volume increases, practically it is observed that the volume of 1 litre of water on freezing increased by 0.09 litre.

Thus Volume of ice = 0.09litre+ 1litre

Volume of ice = 1.09litre

7.3 Calculate the volume of the following objects:

(i) An iron sphere of mass 5 kg, the density of iron is 8200 kgm^{-3}.

(ii) 200 g of lead shot having density 11300 kgm^{-3}.

(iii) A gold bar of mass 0.2 kg. The density of gold is 19300 kgm^{-3}.

(i) Given Data:

Mass of the sphere =m = 5kg
Density of the iron =ρ = 8200kgm^{-3}

Required:

Volume = V =?

Solution:

We know that

$$\rho = \frac{m}{V}$$

$$\rho V = m$$

$$V = \frac{m}{\rho}$$

$$V = \frac{5kg}{8200kgm^{-3}}$$

$$V = 6.1 \times 10^{-4}\ m^3$$

(ii) Given data:

Mass of the lead = m = 200g

$$= \frac{200}{1000} kg$$

m= 0.2kg

Density = ρ = 113000kgm^{-3}

Required:

Volume of the lead = V =?

Solution:

We know that

$$\rho = \frac{m}{V}$$

$$V = \frac{m}{\rho}$$

$$V = \frac{0.2kg}{11300kgm^{-3}}$$

$$V = 1.77 \times 10^{-5}\ m^3$$

(iii) Given data:

Mass of the gold bar = m = 0.2kg

Density = $\rho = 19300kgm^{-3}$

Required:

Volume = V =?

Solution:

We know that

$$\rho = \frac{m}{V}$$

$$V = \frac{m}{\rho}$$

$$V = \frac{0.2kg}{19300kgm^{-3}}$$

$$V = 1.04 \times 10^{-5}\ m^3$$

7.4 The density of air is $1.3kgm^{-3}$. Find the mass of air in a room measuring 8 m × 5 m × 4 m.

Given data:

Density = $\rho = 1.3kgm^{-3}$

Volume = V = 8m × 5m × 4m

$V = 160m^3$

Required:

Mass of the air = m =?

Solution:

We know that

$$\rho = \frac{m}{V}$$

$$\rho V = m$$

$$m = \rho V$$

$m=1.3kgm^{-3} \times 160m^3$

$m = 208kg$

7.5 A student presses her palm by her thumb with a force of 75 N. How much would be the pressure under her thumb having contact area 1.5 cm^2?

Given data:

Force = F = 75N

Area = A = $1.5cm^3$

$A = 1.5 \times (10^{-2}m)^2$ $(\because 1C = 10^{-2})$

$A = 1.5 \times 10^{-4} \times m^2$

Required:

Pressure = P = ?

Solution:

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

$$P = \frac{75N}{1.5 \times 10^{-4}m^2}$$

$P = 50000Nm^{-2}$

$P = 5 \times 10^5 Nm^{-2}$

7.6 The head of a pin is squared of side 10 mm. Find the pressure on it due to a force of 20 N.

Given data:

Length of the side of square pin = L = 10mm

$L = 10 \times 10^{-3}m$ $(\because 1m = 10^{-3})$

$$L=\frac{10}{10^3}m$$

$$L= \frac{10}{1000}m$$

$$L= \frac{1}{100}m$$

$L= 0.01m$

Force = F = 20N

Required:

Pressure = P = ?

Solution:

We know that

$P = \frac{F}{A}$ …….. (i)

As the head of pin is square so

$A = L \times L$

$A = L^2$

Eq (i) becomes

$P = \frac{F}{L^2}$

$P = \frac{20N}{0.01m \times 0.01m}$

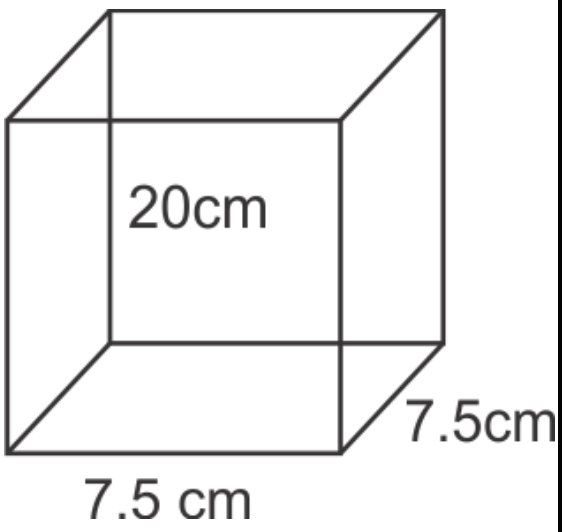
$= \frac{20N}{1 \times 10^{-4}m^2}$

$P = 200000Nm^{-2}$

$P = 2 \times 10^5 Nm^{-2}$

7.7 A uniform rectangular block of wood 20 cm × 7.5 cm × 7.5 cm and of mass 1000g stands on a horizontal surface with its longest edge vertical. Find (i) the pressure exerted by the block on the surface (ii) density of the wood

Given data:



Volume = $V = 20\ cm \times 7.5\ cm \times 7.5\ cm$

$= \frac{20}{100}m \times \frac{7.5}{100}m \times \frac{7.5}{100}m$

$= \frac{1125}{1000000}m^3$

$V = 1.125 \times 10^{-3}m^3$

Mass of the block = m = 1000g

$= \frac{1000}{1000}kg$

$$m = 1kg$$

$$\text{Area} = A = 7.5\ cm \times 7.5\ cm$$

$$A = \frac{7.5}{100}m \times \frac{7.5}{100}m$$

$$A = \frac{56.25m^2}{10000}$$

$$A = 5.625 \times 10^{-3}\ m^2$$

Required:

(i) Pressure = P =?

(ii) Density = ρ =?

Solution:

We know that

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

$$P = \frac{W}{A} \qquad (\because F = W)$$

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

$$P = \frac{1kg \times 10ms^{-2}}{0.015m^2}$$

$$= \frac{10kgms^{-2}}{5.625 \times 10^{-3}m^2}$$

$$P = 1778Nm^{-2} \qquad (\because 1N = 1kgms^{-2})$$

(ii) We know that

$$\rho = \frac{m}{V}$$

$$= \frac{1kg}{1.125 \times 10^{-3}m^3}$$

$$\rho = 889kgm^{-3}$$

7.8 A cube of glass of 5 cm side and mass 306 g, has a cavity inside it.If the density of glass is 2.55 gcm^{-3}. Find the volume of the cavity.

Given data:

Length = L = 5cm

$$L = \frac{5}{100} m$$

$$L = 0.05m$$

Mass = m = 306g

$$m = \frac{306}{1000} kg$$

$$m = 0.306kg$$

Density of glass = $\rho = 2.55 gcm^{-3}$

Required:

Volume of the cavity = V =?

Solution:

Volume of the whole cube = V = 5 cm × 5 cm × 5 cm

$$= 125cm^3$$

$$\text{Density of the glass} = \frac{\text{Mass}}{\text{Volume of the glass}}$$

$$\rho = \frac{m}{V'}$$

$$\rho V' = m$$

$$V' = \frac{m}{\rho}$$

$$V' = \frac{306g}{2.55\,gcm^{-3}}$$

$$V' = 120cm^3$$

Volume of the cavity = V - V′

$$= 125cm^3 - 120cm^3$$

Volume of the cavity = $5cm^3$

7.9 An object has weight 18 N in air. Its weight is founded to be 11.4 N when immersed in water. Calculate its density. Can you guess the material of the object?

Given data:

Weight of object in air = w_1 = 18N

Weight of object in immersed water = w_2 = 11.4N
Density of water = $\rho = 1000 kgm^{-3}$

Required:

Density of the object = D′ =?
Nature of the material =?

Solution:

We know that

$$D = \frac{w_1}{w_1 - w_2} \times \rho$$

$$= \frac{18N}{18N - 11.4N} \times 100 kgm^{-3}$$

$$= \frac{18N}{6.6N} \times 100 kgm^{-3}$$

$$= \frac{18000 kgm^{-3}}{6.6}$$

$$= 2727 kgm^{-3}$$

Density of aluminum is $2700 kgm^{-3}$ so $2727 kgm^{-3}$ is nearest to it. So material of object is aluminum.

7.10 A solid block of wood of density o.6 gcm^{-3} weighs 3.06 N in air. Determine (a) volume of the block (b) the volume of the block immersed when placed freely in a liquid of density 0.9 gcm^{-3}.

Given data:

Density of wood = $0.6 cm^{-3}$
Weight = w = 3.06N
Density of liquid = $\rho = 0.9 cm^{-3}$

Required:

Volume of the block = V =?
b) Volume of the block immersed in a liquid = V′ =?

Solution:

We know that

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Volume} = \frac{\text{Mass}}{\text{Density}} \quad \ldots\ldots\ldots \text{(i)}$$

We know that

$w = mg$

$$\frac{w}{g} = m$$

$$m = \frac{w}{g}$$

$$m = \frac{3.06N}{10ms^{-2}}$$

$$m = \frac{3.06kgms^{-2}}{10ms^{-2}}$$

$m = 0.306kg$

$m = 0.306 \times 1000g = 306g$

Putting all the values in eq (i)

$$V = \frac{306g}{0.6gcm^{-3}}$$

$V = 510cm^3$

b) We know that

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Volume} = \frac{\text{Mass}}{\text{Density}}$$

$$V = \frac{306g}{0.9gcm^{-3}}$$

$V = 340cm^3$

7.11 The diameter of the piston of a hydraulic press is 30 cm. How much force is required to lift a car weighing 20 000 N on its piston if the diameter of the piston of the pump is 3 cm?

Given data:

Diameter of the piston of hydraulic press = D = 30cm

Radius of the piston of hydraulic press = $R = \frac{D}{2}$

$$R = \frac{30cm}{2}$$

$$R = 15cm$$

$$= \frac{15}{100} m$$

$$= 0.15m$$

Weight on larger piston = F_2 = 20000N

Diameter of the smaller piston = 3cm

Radius of the smaller piston = $r = \frac{d}{2}$

$$r = \frac{3cm}{2}$$

$$r = 1.5cm$$

$$r = \frac{1.5}{100} m$$

Required:

Force required to lift a car = F_1 =?

Solution:

We know that

$$F_1 = F_2 \times \frac{d}{A}$$

$$F_1 = F_2 \times \frac{\pi r^2}{\pi R^2}$$

$$F_1 = F_2 \times \frac{r^2}{R^2}$$

$$F_1 = 20000N \times \frac{(0.015m)^2}{(0.15m)^2}$$

$$= \frac{20000N \times 2.25 \times 10^{-4} m}{0.0225m^2}$$

$$F_1 = 200N$$

7.12 A steel wire of cross- sectional area 2×10^{-5} m^2 is stretched through 2 mm by a force of 4000 N. Find the Young's modulus of the wire. The length of the wire is 2 m.

Given data:

Area = A = $2 \times 10^{-5}\, m^2$
Increase in the length of wire = $\Delta L = 2mm = 2 \times 10^{-3} m$
Force = F = 4000N
Length of the wire = L = 2m

Required:

Young's modulus = Y =?

Solution:

We know that

$$Y = \frac{F \times L}{A \times \Delta L}$$

$$Y = \frac{4000N \times 2m}{2 \times 10^{-5} m^2 \times 0.002m}$$

$$Y = \frac{8000N}{4 \times 10^{-8} m^2}$$

$$Y = 2 \times 10^{11} Nm^{-2}$$

Thermal Properties of matter

Encircle the correct answer from the given choices.

i. Water freezes at

(a) 0^oF (b) 32^oF (c) -273 k (d) 0 K

ii. Normal human body temperature is

(a) 15^oC (b) 37^oC (c) 37^OF (d) 98.6^oC

iii. Mercury is used as thermometric material because it has

(a) Uniform thermal expansion

(b) Low freezing point

(c) Small heat capacity

(d) All the above properties

iv. Which of the following material has large specific heat?

(a) copper (b) ice (c) water (d) mercury

v. Which of the following material has large value of temperature coefficient of linear expansion?

(a) aluminum (b) gold (c) brass (d) steel

vi. What will be the value of β for a solid for which α has value of $2\times10^{-5}k^{-1}$?

(a) $2\times10^{-5}k^{-1}$ (b) $6\times10^{-5}k^{-1}$ (c) $8\times10^{-15}k^{-1}$ (d) $8\times10^{-5}k^{-1}$

vii. A large water reservoir keeps the temperature of nearby land moderate due to

(a) Low temperature of water

(b) Low specific heat of water

(c) Less absorption of heat

(d) Large specific heat of water

viii. Which of the following affects evaporation?

(a) temperature (b) surface area of the liquid

(b) wind (d) all of the above

Ans:

i. b ii. b iii. d iv. c v. a vi. b vii. d viii. d

Exercise Short Questions

Q.8.2 Why does heat flow from hot body to cold body?

Ans. Temperature determines the direction of flow of heat. Heat flows from higher temperature to lower temperature. As the temperature of hot body is more than the cold body, therefore heat flows from hot body to cold body.

Q.8.2 Define the terms heat and temperature.

Ans. Heat: "Heat is the energy that is transferred from one body to the other in thermal contact with each other as a result of the difference of temperature between them." Its unit is joule (J).

Temperature: "Temperature of a body is the degree of hotness or coldness of the body." Its SI unit is kelvin (K).

Q.8.4 What is meant by internal energy of a body?

Ans. "The sum of kinetic energy and potential energy associated with the atoms, molecules and particles of a body is called its internal energy."

Internal energy of a body depends upon factors such as the mass of the body, kinetic energy and potential energy etc.

Q.8.5 How does heating affect the motion of molecules of a gas?

Ans. When a gas is heated, the kinetic energy of gas molecules goes on increasing. This causes the gas molecules to move with higher velocities. During their random motion they collide with each other and also with the walls of the container. Thus, they put pressure on the walls of the container.

Q.8.6 What is thermometer? Why mercury is preferred as thermometric substance?

Ans. "A device that is used to measure the temperature of a body is called thermometer."

Mercury is preferred as a thermometric substance because it has all the thermometric properties. Mercury freezes at -39°C and boils 375°C.Thus mercury is one of the most suitable thermometric material.

Q.8.7 Define specific heat. How would you find the specific heat of a solid?

Ans. "Specific heat of a substance is the amount of heat required to raise the temperature of 1kg mass of that substance through 1k." It is denoted by 'c' .Its SI unit is $JKg^{-1}k^{-1}$.

Specific heat of a substance 'c' is calculated by following equation:

$$c=\frac{\Delta Q}{m\Delta T}$$

Where ΔQ is amount of heat absorbed by a body, m is the mass of a body and ΔT is raised temperature of a body.

Q.8.9 Define latent heat of fusion.

Ans. "Heat energy required to change unit mass of a substance from solid to liquid state at its melting point without change in its temperature is called its latent heat of fusion." It is denoted by H_f. Its SI unit is JKg^{-1}.

Its formula is:

$$H_f = \frac{\Delta Q_f}{m}$$

Q.8.10 Define latent heat of vaporization.

Ans. "The quantity of heat that changes unit mass of a liquid completely into gas at its boiling point without any change in its temperature is called its latent heat of vaporization." It is denoted by H_v. Its SI unit is JKg^{-1}. Its formula is:

$$H_v = \frac{\Delta Q_v}{m}$$

Important Formulas ,Units and Values

$T(K) = 273 + C$

$F = 1.8\,C + 32$

$L = L_o(1+\alpha\Delta T)$

$V = V_O(1+\beta\Delta T)$

$Q = mc\Delta T$

$\Delta Q_f = m H_f$

$\Delta Q_v = m H_v$

SI unit for Q, ΔQ_f, ΔQ_v is joule (J)

SI unit for H_f and H_v JKg^{-1}.

Specific heat of ice is $2100 Jjkg^{-1}k^{-1}$,

Specific heat of water is $4200 Jkg^{-1}k^{-1}$,

Latent heat of fusion of ice is $336000\ Jkg^{-1}$

Latent heat of vaporization of water is 2.26×10^6 JKg^{-1}

Problems

8.1 Temperature of water in beaker is 50°C. What is its value in Fahrenheit scale?

Given Data:

Temperature in Celsius scale = C = 50°

Required:

Temperature in Fahrenheit = F =?

Solution:

We know that

$$F = 1.8C + 32$$
$$= 1.8 \times 50 + 32$$
$$= 90 + 32$$
$$F = 122°$$

8.2 Normal human body temperature is 98.6°F. Convert it into Celsius scale and kelvin scale.

Given Data:

Normal human body temperature in Fahrenheit scale = F = 98.6°F

Required:

Normal human body temperature in Celsius scale = C =?
Normal human body temperature in Kelvin scale = T(K) =?

Solution:

We know that

$$F=1.8C+32$$

$$F-32=1.8C$$

$$\frac{F-32}{1.8}=C$$

$$C=\frac{F-32}{1.8}$$

$$C=\frac{98.6-32}{1.8}$$

$$C=37°$$

We know that

$$T(K) = C + 273$$
$$= 37 + 273$$

$$T(K) = 310K$$

8.3 Calculate the increase in the length of an aluminum bar 2 m long when heated from 0^oC to 20^oC.If the thermal coefficient of linear expansion of aluminum is $2.5\times10^{-5}k^{-1}$.

Given Data:

Length of the aluminum bat = $L_o = 2m$

Initial temperature $= T_o = 0°C$
$= 0 + 273$
$T_o = 273K$

Final temperature $= T = 20°C$
$T = 20 + 273$
$T = 293K$

$$\Delta T = T - T_o$$

$$= 293K - 273K$$

$$\Delta T = 20K$$

Thermal coefficient of aluminum = $\alpha = 2.5 \times 10^{-5}\ K^{-1}$

Required:

We know that

$$L = L_o(1+\alpha\Delta T)$$
$$L = L_o + L_o\alpha\Delta T$$

$L - L_o = L_o \alpha \Delta T$

$\Delta L = L_o \alpha \Delta T \quad (\because L = L - L_o)$

$\Delta L = 2m \times 2.5 \times 10^{-5} K^{-1} \times 20K$

$= 1\times10^{-3}m$

$= 1\times10^{-3} \times 100cm$

$= 1\times10^{-3} \times 10^{-2}cm$

$= 1\times10^{-3+2}cm$

$= 1\times10^{-1}$

$= \frac{1}{10}cm$

$\Delta L = 0.1cm$

8.4 A balloon contains 1.2 m^3 air at 15°C. Find its volume at 40°C.Thermal coefficient of volume expansion of air is $3.67\times10^{-3}K^{-1}$

Given Data:

Volume of the balloon = $V_o = 12m^3$

Initial temperature = $T_o = 15°C$

$= 15 + 273$

$T_o = 288K$

Final temperature = $T = 40°C$

$= 40 + 273$

$T = 313K$

$\Delta T = T - T_o$

$= 313K – 288K$

$\Delta T = 25K$

Thermal coefficient of volume expansion of air = $\beta = 3.67 \times 10^{-3}K^{-1}$

Required:

Volume of balloon at $40°C$ = V =?

Solution:

$V = 1.2m^3(1 + 3.67 \times 10^{-3}K^{-1} \times 25K)$

$= 1.2m^3(1 + 0.09175)$

$= 1.2m^3(1.09175)$

$V = 1.3m^3$

8.5 How much heat is required to increase the temperature of 0.5 kg of water from 10°C to 65°C?

Given Data:

Mass of the water = m = 0.5kg

Initial temperature = $T_o = 10°C$

$= 10 + 273$

$= 283K$

Final temperature = $T = 65°C$

$= 65 + 273$

$= 338K$

$\Delta T = T - T_o$

$= 338K - 283K$

$= 55K$

Specific heat of water = $c = 4200 Jkg^{-1}K^{-1}$

Required:

Heat required = $\Delta Q = ?$

Solution:

We know that

$\Delta Q = mc\Delta T$

$= 0.5kg \times 4200 Jkg^{-1}K^{-1} \times 55K$

$\Delta Q = 115500J$

8.6 An electric heater supplies heat at the rate of 1000 joule per second. How much time is required to raise the temperature of 200g of water from 20^oC to 90^oC.

Given Data:

Rate of heat supply = $P = \frac{Q}{t} = 1000 Js^{-1}$

Mass of the water = m = 200g

$m = \frac{200}{100} kg$

$m = 0.2kg$

Initial temperature = $T_o = 20°C$

$= 20 + 273K$

$T_o = 293K$

Final temperature = $T = 90°C$

$$T = 90 + 273$$
$$T = 363K$$
$$\Delta T = T - T_o$$
$$= 363K - 293K$$
$$\Delta T = 70K$$

Required:

Time required = t =?

Solution:

We know that

$$P = \frac{Q}{t}$$
$$Pt = Q$$
$$t = \frac{Q}{P}$$
$$t = \frac{mc\Delta T}{P}$$
$$t = \frac{0.2kg \times 4200Jkg^{-1}K^{-1} \times 70k}{1000Js^{-1}}$$
$$= \frac{58800}{1000s^{-1}}$$
$$= \frac{588s}{10}$$
$$t = 5.88s$$

8.7 How much ice will melt by 50000 J of heat? Latent heat of fusion of ice = 336000 Jkg^{-1}.

Given Data:

Heat required to melt the ice = ΔQ_f = 50000J

Latent heat of fusion of ice = H_f = 36000Jkg^{-1}

Required:

Mass of ice = m =?

Solution:

$\Delta Q_f = mH_f$

$\frac{\Delta Q_f}{H_f} = m$

$m = \frac{\Delta Q_f}{H_f}$

$= \frac{50000J}{336000Jkg^{-1}}$

$= \frac{50kg}{336}$

$= 0.1488kg$

$= 0.1488 \times 1000g$

$= 148.8g$

$m = 150g$ (Approximately)

8.8 Find the quantity of heat needed to melt 100g of ice at -10°C into water at 10°C (Note: Specific heat of ice is 2100Jjkg^{-1}k^{-1},Specific heat of water is 4200Jkg^{-1}k^{-1}, Latent heat of fusion of ice is 336000 Jkg^{-1})

Given Data:

Mass of the ice = $m = 100g$

$m = \frac{100}{1000}kg$

Specific heat of ice = $c_1 = 2100Jkg^{-1}K^{-1}$

Specific heat of water = $c_2 = 4200Jkg^{-1}K^{-1}$

Latent heat of fusion of ice = $H_f = 336000Jkg^{-1}K^{-1}$

Initial temperature = $T_1 = -10°C$

$T_1 = -10 + 273$

$T_1 = 263K$

Temperature of ice = $T_2 = 0°C$

$T_2 = 0 + 273$

$T_2 = 273K$

Temperature of water = $T_3 = 10°C$

$T_3 = 10 + 273$

$T_3 = 283K$

Required:

Heat required = Q =?

Solution:

Heat absorbed by the ice to change temperature from $-10°C$ to $0°C = Q_1 = mc_1\Delta T$

$Q_1 = 0.1kg \times 2100Jkg^{-1}K^{-1} \times 10K$
$Q_1 = 2100J$

Heat required by ice to melt $= Q_2 = mH_f$
$Q_2 = 0.1kg \times 336000Jkg^{-1}$

$Q_2 = 336000J$

Heat required to raise the temperature from $0°C$ to $10°C = Q_3 = mc_2\Delta T$
$Q_3 = 0.1kg \times 4200Jkg^{-1}K^{-1} \times 10K$
$Q_3 = 4200J$

Heat required $Q = Q_1 + Q_2 + Q_3$
$Q = 2100J + 33600J + 4200J$
$Q = 39900J$

8.9 How much heat is required to change 100g of water at 100°C into steam? (Latent heat of vaporization of water is 2.26×10^6 JKg^{-1})

Given Data:

Mass of water = m = 100g

$$m = \frac{100}{1000}kg$$

$$m = 0.1kg$$

Temperature $= T_1 = 100°C$
$= 100 + 273$
$T_1 = 373K$

Temperature of water $= T_2 = 10°C$
$T_2 = 10 + 273$

$T_2 = 283K$
$\Delta T = T_1 - T_2$
$\Delta T = 373K - 283K$
$\Delta T = 90K$

Latent heat of vaporization of water $= H_v = 2.26 \times 10^6 Jkg^{-1}$

Required:

Heat required = ΔQ_v **=?**

Solution:

We know that

$\Delta Q_v = mH_v$

$= 0.1kg \times 2.26 \times 10^6 Jkg^{-1}$

$\Delta Q_v = 0.226 \times 10^6 J$

8.10 Find the temperature of water after passing 5 g of steam at 100^oC through 500g of water at 10^oC.(Note: Specific heat of water is $4200JKg^{-1}$, Latent heat of vaporization of water is 2.26×10^6 Jkg^{-1})

Given Data:

Mass of the steam = $m_1 = 5g$

$m_1 = \frac{5kg}{1000}$

$m_1 = 0.005kg$

Mass of the water = $m_2 = 500g$

$= \frac{500}{1000} kg$

$m_2 = 0.5kg$

Temperature of steam = $T_1 = 100°C$

$T_1 = 100 + 273$

$T_1 = 283K$

Temperature of water = $T_2 = 10°C$

$T_2 = 10 + 273$

$T_2 = 283K$

Latent heat of vaporization of water = $H_v = 2.26 \times 10^6 Jkg^{-1}$

Required:

Temperature of mixture = T_3=?

Solution:

We know that

Latent heat lost by steam = $Q_1 = mH_v$

$Q_1 = 0.005kg \times 2.26 \times 10^6 Jkg^{-1}$

$Q_1 = 11.3 \times 10^3 J$

Heat lost by system to attain final temperature = $Q_2 = m_2 c\Delta T$

$Q_2 = 0.005kg \times 4200Jkg^{-1}K^{-1} \times (273 - T_3)K$
$Q_2 = 21J(273 - T_3)$

Heat gained by water = $Q_3 = m_2c\Delta T$

$Q_3 = 0.5kg \times 4200Jkg^{-1}K^{-1} \times (T_3 - 283)K$
$Q_3 = 2100J(T_3 - 283)$

According to law of heat exchange

Heat lost = Heat gained
$Q_1 + Q_2 = Q_3$
$11.3 \times 10^3J + 21J(373 - T_3) = 2100J\ (T_3 - 283)$
$11300J + 7833J - 21JT_3 = 2100JT_3 - 594300J$
$11300J + 7833J + 594300J$
$613433J = 21JT_3 + 2100JT_3$
$613433J = 2121JT_3$

$$T_3 = \frac{613433J}{2121J}$$

$T_3 = 289.2K$
$T_3 = 289.2 - 273$
$T_3 = 16.2°$

Transfer of Heat

Encircle the correct answer from the given choices:

i. In solids, heat is transferred by:
(a) radiation (b) conduction

(c convection (d) absorption

ii. What happens to the thermal conductivity of a wall if its thickness is doubled?
(a) becomes double (b) remains the same
(c) becomes half (d) becomes one forth
Explanation:
We know that $k = \frac{Q}{t} \times \frac{L}{A(T_1 - T_2)}$

$k \propto L$

Thermal conductivity of a wall becomes double if its thickness is doubled.

iii. Metals are good conductor of heat due to the:

(a) Free electrons

(b) big size of their molecules

(c) small size of their molecules

(d) rapid vibration of their molecules

iv. In green, heat is mainly transferred by

(a) molecules collision
(b) conduction
(c) Convection
(d) Radiation

v. Convection of heat is the process of heat transfer due to the:

(a) random motion of molecules

(b) downward movement of molecules

(c) upward movement of molecules

(d) free movement of molecules

vi. False ceiling is done to:

(a) Lower the height of ceiling
(b) Keep the roof clean
(c) Cool the room
(d) Insulate the ceiling

vii. Rooms are heated using gas heaters by :

(a) Conduction only
(b) Convection and radiation only
(c) Radiation only
(d) Convection only

viii. Land breeze blows from:

(a) Sea to land during the night
(b) Sea to land during the day
(c) Land to sea during night
(d) Land to sea during the day

ix. Which of following is a good radiator of heat?

(a) A shining silvered surface
(b) A dull black surface
(c) A white surface
(d) A green coloured surface

Ans:

i. b ii. a iii. a iv. c v. c vi. d vii. d viii. c ix. b

Exercise Short Questions

Q.9.2 Why metals are good conductor of heat?

Ans. Metals have free electrons. These free electrons move with very high velocities within the metal objects. They carry energy at a very fast rate from hot to cold parts of the objects as they move .That is why metals are good conductors of heat than non-metals.

Q.9.3 Explain why

(a) A metal feels colder to touch than wood kept in a cold place?

Ans. Good heat absorber is also good heat emitters and bad heat absorber are also bad heat emitters. As metals are good heat absorber as compared to wood, thus, a metal emits heat at faster rate than the wood which is a bad heat emitter. Thus, a metal feels colder to touch than wood when kept in a cold place.

(b) Land breeze blows from land towards sea?

Ans. At night, the land cools faster than the sea. Therefore air above the sea is warmer, rises up and cold air from the land begins to move towards the sea. It is called land breeze.

(c) Double walled glass vessel is used in thermos flask?

Ans. Double walled glass vessel is used in thermos flask because most of the heat is prevented to enter or leave the flask .There is air between double walled glass vessel which is bad conductor of heat.

(d) Deserts soon get hot during the day and soon get cold after sunset?

Ans. Deserts are good heat absorber due to high thermal conductivity of sand .Since good heat absorbers are good heat emitters. Thus, deserts soon get hot during the day and soon get cold after sunset.

Q.9.4 Why conduction of heat does not take place in gases?

Ans. Conduction is the mode of transfer of heat by vibrating atoms and free electrons in solids from hot to cold parts of a body. In gases atoms are far apart. Thus, there is a very small chance of collisions between their atoms. Gases do not have free electrons. That is why conduction of heat does not take place in gases.

Q.9.5 What measures do you suggest to conserve energy in houses?

Ans. Following measures may be taken to conserve energy in houses

(i) Hot water tanks are insulated by plastic or foam lagging.
(ii) Wall cavities are filled with plastic foam or wool.
(iii) Ceiling of rooms is covered by insulating materials (False Ceiling)
(iv) Double glazed window panes are used.

Q.9.6 Why transfer of heat in fluids takes place by convection?

Ans. Convection is a mode of transfer of heat by actual movement of molecules from hot place to a cold place. In fluids (liquids and gases), due to weak intermolecular forces, molecules are free to move from one place to another place. Thus, in fluids transfer of heat takes place easily by convection.

Q.9.7 What is meant by convection current?

Ans. Gases also expands on heating, thus convection currents are easily set up due to the differences in the densities of air at various parts in the atmosphere.

Q. 9.8 Suggest a simple activity to show convection of heat in gases not given in the book.

Ans. In summer season the intense radiations of the Sun warms the surface of the land. The air on heating expands. Its density decreases due to increase in volume. Because of this air above the surface of the land rises up. Cold air begins to move towards the land. This results conventional current of air.

Q.9.9 How does heat reach us from the Sun?

Ans. Heat from the Sun reaches us neither by conduction nor by convection, because the space between the Sun and the Earth's atmosphere is empty. There is a third mode called radiation by which heat travels from one place to another. It is through radiation that heat reaches us from the Sun.

Q.9.10 How various surfaces can be compared by Leslie cube?

Ans. A Leslie cube is a metal box having faces of different nature. The four sides of Leslie's cube may be of following nature:

(1) a shining silvered surface
(2) a dull black surface

(3) a white surface
(4) a coloured surface

Due to difference in nature of faces, the emittance, absorption and reflection of heat is of different amount from sides of Leslie cube.

Q.9.11 What is greenhouse effect?

Ans. Gases like carbon dioxide and water vapours absorbs high temperature thermal radiations but these are opaque to low temperature thermal radiations. This ability of carbon dioxide and water vapours in the atmosphere to pass solar energy to the Earth but block environmental radiations back into space is known as greenhouse effect. This effect has caused an increase in the average temperature of the Earth.

Q.9.12 Explain the impact of greenhouse effect in global warming.

Ans. Earth's atmosphere contains carbon dioxide and water vapours. Gases like carbon dioxide and water vapours high temperature thermal radiations but block environmental radiation back into space. Thus maintains the temperature of the Earth. During the recent years, the percentage of carbon dioxide has been increased considerably. This has caused an increase in the average temperature of the Earth by trapping more heat due to greenhouse effect. This phenomenon is known as global warming. This has serious implications for the global climate.

Important Formulas, Units and values:

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

Unit of Q (heat) is joule (J).

Unit of $\frac{Q}{t}$ (rate of flow of thermal energy) is Js^{-1}.

Problems:

9.1 The concrete roof of a house thickness 20 cm has an area 200 cm^2. The temperature inside the house is 15^oC and outside is 35^oC.Find the rate at which thermal energy will be conducted through the roof. The value of k for concrete is o.65 $Wm^{-1}k^{-1}$?

Given data:

Thickness of the roof =L = 20 cm

$$L = \frac{20}{100}\ m$$

$$L = 0.2\ m$$

Temperature inside the house $= T_2 = 15^oC$

$$T_2 = 15 + 273$$

$$T_2 = 288\ K$$

Temperature outside the house $= T_1 = 35^oC$

$$T_1 = 35 + 273$$

$$T_1 = 308\ K$$

$$\Delta T = T_1 - T_2$$

$$\Delta T = 308K - 288K$$

$$\Delta T = 20K$$

$$k = 0.65\ Wm^{-1}k^{-1}$$

Required:

Rate of conduction of thermal energy $= \frac{Q}{t} = ?$

Solution:

We know that

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

$$\frac{Q}{t} = \frac{0.65 Wm^{-1}k^{-1} \times 200\ m^2 \times 20\ k}{0.2\ m}$$

$$\frac{Q}{t} = \frac{2600 Wm^{-1+2}k^{-1+1}}{0.2\ m}$$

$$\frac{Q}{t} = \frac{2600 Wmk^0}{0.2\ m}$$

$$\frac{Q}{t} = \frac{2600W \times 1}{0.2}$$

$$\frac{Q}{t} = 1300\ W$$

$$\frac{Q}{t} = 1300\ Js^{-1} \qquad (\therefore 1W = Js^{-1})$$

9.2 How much heat is lost in an hour through a glass window measuring 2.0 m by 2.5 m when inside temperature is 25°C and that of outside is 5°C, the thickness of glass is 0.8 cm and the value of k for glass is 0.8 $Wm^{-1}k^{-1}$?

Given data:

Time = t= 1 hour

$t = 1 \times 60 \times 60\ s$

$t = 3600\ s$

Area of glass window = A = 2.0 m × 2.5 m

$A = 5\ m^2$

Inside temperature = $T_1 = 25\ ^oC$

$T_1 = 25 + 273$

$T_1 = 298\ K$

Outside temperature= $T_2 = 5^oC$

$T_2 = 5 + 273$

$T_2 = 278K$

$\Delta T = T_1 - T_2$

$\Delta T = 298K - 278K$

$\Delta T = 20\ K$

Thickness of the roof =L = 0.8 cm

$$L = \frac{0.8}{100}\ m$$

$L = 0.008\ m$

$k = 0.8\ W\ m^{-1}K^{-1}$

Required:

Heat lost = Q=?

Solution:

We know that

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

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

$$Q = \frac{0.8 W m^{-1}k^{-1} \times 5\ m^2 \times 20\ k \times 3600\ s}{0.2\ m}$$

$$Q = \frac{28800 W m^{-1+2}k^{-1+1}\ s}{0.008\ m}$$

$$Q = \frac{28800 W m k^{o} s}{0.008\ m}$$

$$Q = \frac{28800 W\ s}{0.008}$$

$$Q = 36000\ 000\ W\ s$$

$$Q = 36000\ 000\ J/s \times s$$

$$Q = 36000\ 000\ J$$

If any teacher or student find these notes helpful ,kindly remember me in your precious prayers