# Lesson No. 3
# Work, Power and Energy

⇨ ***Key terms:***

1) **Work:** Work is said to be done by a force when acting on a body produces displacement in the direction of force. It is equal to the product of force and displacement, it is denoted by W. If F is the force and S is the displacement $W = F \times S$

2) **Joule :** It is the amount of work done on an object when a force of IN displaces it by 1m along the line of action of the force.

$1T = 1Nm$ (where 1N = Newton)

3) **Kinetic Energy:** It is the amount of work done on a body to make it move with a certain velocity. It is the energy possessed by a body by virtue of its motion. K.E = ½ mv2 (Where m is the mass of body moving with a velocity of V.

**4) Gravitational Potential energy:** It is defined as the work done in raising it from the ground to a particular point against gravity. It is the energy possessed by a body by virtue of its position or configuration.

5) **Law of conservation of energy:** According to this law, the total energy before and after transformation remains the same i.e. total energy of the system remains unchanged. Total energy = K.E + P.E. Total energy is equal to the sum of Kinetic energy and Potential energy.

6) **Power:** It is defined as the rate of doing work or the rate of transfer of energy.

7) **Watt:** Power of a body is said to be 1watt (w), when 1Joule (J) of energy is consumed or transferred in 1seconds (S).

8) **Kilowatt hour (KWh):** It is the amount of electric energy consumed in one hour at the rate of $1000\ Js^{-1}$(1kw).

**9) Acceleration due to gravity(g):** It is the acceleration produced in a body under the action of gravity.

**Formula and units**

1) Work done = Force x displacement

$W = F \times S$

2) Kinetic Energy $(E_k) = \frac{1}{2} m (v^2 - u^2) = ?$

3) Gravitational Potential energy $(E_p) = mgh$

4) $\text{Power} = \frac{\text{Work done}}{\text{time}}$

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

5) $1\ kwh = 3.6 \times 10^6\ J \quad (1KW = 1000Js^{-1})$

$1KWh = 1000Js^{-1} \times 60$ minutes

$1KWh = 1000Js^{-1} \times 60 \times 60s$

$= 1000J \times 3600$

$= 36 \times 10^5 J$

$= 3.6 \times 10^6 J$

6) Acceleration due to gravity (g) = 9.8 $m/s^2$ => S.I units of Physical quantities :

| | Physical quantity | S.I unit |
|---|---|---|
| a) | Work | Joule (J) |
| b) | Energy | Joule (J) |
| c) | Power | Watt (W) |
| d) | Force | Newton (N) |
| e) | Displacement | Metre (m) |
| f) | Time | Second (s) |
| g) | Velocity | metres per second ($ms^{-1}$) |

## *Textual Questions*

### *Section A (P.No.43)*

***Q.1) A force of 7N acts on an object. The displacement is, say 8m, in the direction of the force. Let us take it that the force acts on the object through the displacement. What is the work done in this case?***

Ans) Here force = 7N

Displacement = 8m

Work = force x displacement

= W = 7N x 8m

= 56 Nm

### *Section B (P.No. 44)*

***Q.1) When do we say that work is done?***

Ans) Work is said to be done by a force when acting on a body produces displacement in the direction of force. It is equal to the product of force and displacement, it is denoted by W. If F is the force and S is the displacement W = F x S

***Q.2) Write an expression for the work done when a force is acting on an object in the direction of its displacement?***

Ans) W = F x S

***Q.3) Define 1 J of work?***

Ans) W = F x S

If F = 1 N, S = 1 m

∴ W = 1 N x 1 m = 1 Nm or 1 Joule

Thus 1 joule is the amount of workdone on an object when a force of 1 N displaces it by 1 m along the line of action of force.

***Q.4) A pair of bullocks exerts a force of 140 N on a plough. The field being ploughed is 15 m long. How much work done is ploughing the length of the field?***

Ans) Here force (F) = 140 N

Displacement (S) = 15 m

∴ Workdone = F x S

= 140 N x 15 m

= 2100 Joules

## *Section C (P.No. 48)*

***Q.1) What is the kinetic energy of an object?***

Ans) The energy possessed by virtue of its motion is called its kinetic energy.

***Q.2) Write an expression for the kinetic energy of an object?***

Ans) K.E = ½ $mv^2$ where m = mass of object & V = velocity of object

***Q.3) The kinetic energy of an object of mass m moving with a velocity of 5 $ms^{-1}$ is 25 J. What will be its kinetic energy when its velocity is doubled? What will be its kinetic energy when its velocity is increased three times?***

Ans) Here K.E = 25 J

V = 5ms-1

M = ?

We know

K.E = ½ $mv^2$

= 25 = ½ m x $(5)^2$

= 25 = ½ m x 25

= $^{25}/_{25}$ = ½ m

or ½ m = 1

= m = 2 kg

If velocity is doubled

= v = 2 x 5 m/s = 10 m/s

∴ K.E = ½ $mv^2$ = ½ x 2 x $(10)^2$

= 10 x 10

= 100 Joules

If velocity is tripled

∴ v = 5 x 3 m/s = 15 m/s

∴ K.E = ½ $mv^2$

= ½ x 2 x $(15)^2$ = 15 x 15

= 225 Joules

## *Section D (P.No. 55)*

***Q.1) What is power?***

Ans) Power is defined as the rate of doing work or the rate of transfer of energy.

***Q.2) Define 1 watt of power?***

Ans) Power = $\frac{\text{workdone}}{\text{Time}}$

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

T

If W = 1 joule & T = 1 S

= P = 1 Joule = 1 J/S = 1 watt

1 second

Hence 1 watt is the power of the agent which does work at the rate of 1 joule per second.

***Q.3) A lamp consumes 1000 J of electrical energy in 10 s. What is its power?***

Ans) W = 100 J

T = 10 S

= P = 100 J = 10 watt

10 S

***Q.4) Define average power?***

Ans) Since the power of an agent may vary with time. Therefore we use the concept of average power. We obtain average power by dividing total energy consumed by the total time taken.

## Section E (P.No. 57)

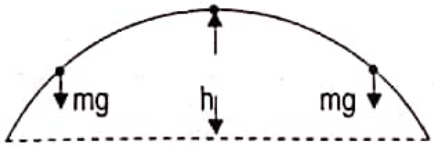
***Q.1) Look at the activities listed below. Reason out whether or not work is done in the light of your understanding of the term 'work'***

***(i) Suma is swimming in a pond.***
***(ii) A donkey is carrying a load on its back.***
***(iii)A wind-mill is lifting water from a well.***
***(iv)A green plant is carrying out photosynthesis.***
***(v) An engine is pulling a train.***
***(vi) Food grains are getting dried in the sun.***
***(vii) A sailboat is moving due to wind energy.***

Ans. Work is done (a) when a force acts (b) the force creates a displacement of the body and (c) the angle between force (F) and displacement (S) is not $90^0$.

(i) Yes, Because Suma does action on water by moving the water back and in turn water pushes Suma forward by the reaction force.
(ii) No, this is because donkey is applying a force on the load in the vertically upward direction. There is not displacement (s). Therefore, work is zero.
(iii)Yes, Work is done in lifting water up against the gravitational pull.
(iv)No, In a chemical reaction, no work is done.
(v) Yes, Force is exerted by the engine on the train in order to pull the train.
(vi)No, No force is being exerted.
(vii) Yes, Wind exerts a force on the sailboat which moves the boat.

***Q.2) An object thrown at a certain angle to the ground moves in a curved path and falls back to the ground. The initial and the final points of the path of the object lie on the same horizontal line. What is the work done by the force of gravity on the object?***



**Ans.** Work done by the force of gravity on the object is zero. This is because in the upper journey work done by the gravity is negative (−mgh) whereas in the downward journey an equal positive work (+mgh) is done by the force of gravity. Therefore, the total work is zero.

***Q.3) A battery lights a bulb. Describe the energy changes involved in the process.***

Ans. The chemical energy of the battery converts into electric energy which converts into light and heat energy in the bulb.

***Q.4) Certain force acting on a 20 kg mass changes its velocity from 5 $ms^{-1}$ to 2 $ms^{-1}$. Calculate the work done by the force.***

Ans. Mass (m) = 20kg initial velocity (u) = 5m/s

Final velocity (v) = 2m/s

Using $2aS = u^2 - v^2$ ------- (1) (where a is acceleration and S is displacement)

We know F = ma or ma = F or a = F/m

Substituting a by F/m in equation (1) we get

$2\ {}^{F}/_{m}\ S = (5m/s)^2 - (2m/s)^2 = 25m^2/s^2 - 4m^2/s^2 = 21m^2/s^2$

or $2FS/m = 21\ (m^2/s^2)$

or $FS = 21(m^2/s^2) \times {}^{m}/_{2} = \frac{21(m^2/s^2) \times 20kg}{2} = 210kg\ m^2/s^2$

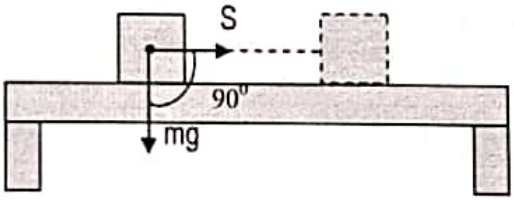
$FS = 210J$ -------- (2) $(Kg\ m^2/s^2 = j)$

We know W = FS ----------(3)

From equation (2) and (3) we have

W = 210 J

***Q.5) A mass of 10 kg is at a point A on a table. It is moved to a point B. If the line joining A and B is horizontal, what is the work done on the object by the gravitational force? Explain your answer.***




Ans. Work done on the object by the gravitational force *mg* is

$W = (mg) \times s \times \cos 90^0 = 0$

***Q.6) The potential energy of a freely falling object decreases progressively. Does this violate the law of conservation of energy? Why?***

Ans. No. Because the potential energy is converted into kinetic energy during free fall. Therefore, total energy remains conserved and law of conservation of energy is not violated.

***Q.7) What are the various energy transformations that occur when you are riding a bicycle?***

Ans. The muscular energy of the cyclist is converted into kinetic energy of the bicycle. A small amount of heat is also produced between the tyres and the road due to force of friction.

***Q.8) Does the transfer of energy take place when you push a huge rock with all your might and fail to move it/ where is the energy, you spend, going?***

Ans. There is no transfer of energy between you and the rock. But you do work to expand and contract your muscles and to circulate blood faster than the normal rate. This means that your energy is spent on yourself.

***Q.9) A certain household has consumed 250 units of energy during a month. How much energy is this in joules?***

Ans. 1 unit = 1 kWh = $3.6 \times 10^6$ J

The energy consumed = 250 units 1 unit = $3.6 \times 10^6$J

Energy consumed = 250 units = $3.6 \times 10^6 J \times 250$

Energy consumed = $900 \times 10^6 j = 9 \times 10^8 j$

***Q.10) An object of mass 40 kg is raised to a height of 5m above the ground. What is its potential energy? If the object is allowed to fall, find its kinetic energy when it is half-way down.***

Ans. The potential energy of the object = mgh

$= 40 \times 10 \times 5 = 2000$ J

$m = 40kg$, $h = 5m$ $g = 9.8m/s^2$

The potential energy = mgh

$= 40kg \times 9.9m/s^2 \times 5m$

When the object is half way the P.E = $\frac{mgh}{2}$

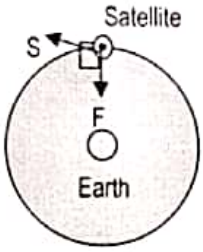
X is the initial P.E and y is the P.E at half way

Initial P.E – P.E at half way = change in P.E

Decrease in P.E at half way has been conserved in K.E.

Thus K.E = decrease in P.E.

***Q.11) What is the work done by the force of gravity on a satellite moving round the earth? Justify your answer.***




Ans. Zero. Since the angle between the force of gravity on the satellite and the displacement of the satellite is $90^0$, therefore, work done is zero.

***Q.12) Can there be displacement of an object in the absence of any force acting on it? Think. Discuss this question with your friends and teacher.***

Ans. Yes, if an object is moving initially then without the action of the force, the object will remain in motion and carry out its displacement.

***Q.13) A person holds a bundle of hay over his head for 30 minutes and gets tired. Has he done some work or not? Justify your answer.***

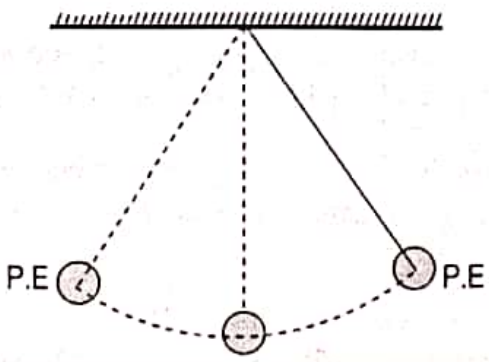
Ans. Work done by the person on the bundle of hay is zero. This is because there is not displacement of the bundle.

***Q.14) An electric heater is rated 1500 W. How much energy does it use in 10 hours?***

Ans. Power = $\frac{\text{Energy}}{\text{Time}}$

$\therefore$ Energy = Power x Time $= 1500\ W \times 10h = 15000\ Wh = 15\ kWh$ (units)

***Q.15) Illustration the law of conservation of energy by discussing the energy changes which occur when we draw a pendulum bob to one side and allow it to oscillate. Why does the bob eventually come to rest? What happens to its energy eventually? Is it a violation of the law of conservation of energy?***



K.E

Ans. When the pendulum oscillates, the energy of the bob at an extreme end is potential energy. When it moves towards the mean position the potential energy decreases and converts into kinetic energy. At the mean position, the total energy is kinetic energy. The total energy at all points remains the same if resistance forces (like air resistance) are absent. In the presence of air resistance some energy of the bob is used up in displacing air and therefore its energy goes on decreasing and ultimately it will stop. The energy of bob is transferred to air as the kinetic energy of air molecules.

***Q.16) An object of mass m is moving with a constant velocity v. How much work should be done on the object in order to bring the object to rest?***

Ans. The kinetic energy of the object is $\frac{1}{2} mv^2$. When the object comes to rest, the kinetic energy becomes zero. The work required to bring the object to rest is equal to its K.E, as K.E = $\frac{1}{2} mv^2$ therefore $\frac{1}{2} mv^2$ is the work required to bring the object to rest.

***Q.17) Calculate the work required to be done to stop a car of 1500 kg moving at a velocity of 60 km/h?***

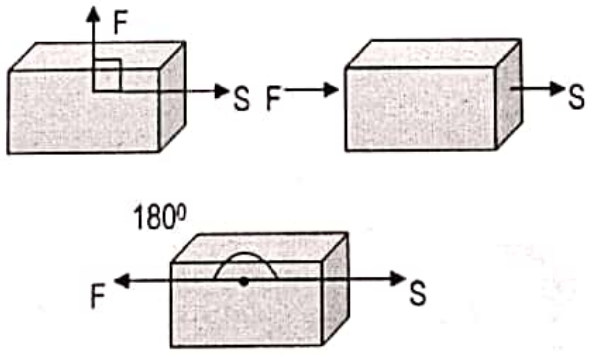
**Ans.** Mass (m) = 1500 kg velocity (v) = 60 km/hour

$$V = \frac{60 \times 1000 \text{ m}}{60 \times 60 \text{ s}} = \frac{100}{6} \text{ m/s}$$

$$K.E = \frac{1}{2} mv2 = \frac{1}{2} \times 1500 \text{ kg} \times \left(\frac{100}{6} \text{ m/s}^2\right)$$

$$= \frac{1}{2} \times 1500 \text{ kg} \times \frac{10000}{36} \text{ m}^2/\text{s}^2$$

***Q.18) In each of the following force, F is acting on an object of mass m. The direction of displacement is from west to east shown by the longer arrow. Observe the diagrams carefully and state whether the work done by the force is negative, positive or zero.***




Ans. Angle between force and displacement is $90^0$. Therefore, W = 0

Angle between force and displacement is $0^0$.

Therefore, work done is positive.

Angle between force and displacement is $180^0$

Therefore, work done is negative.

***Q.19) Soni says that the acceleration in an object could be zero even when forces are acting on it. Do you agree with her? Why?***

Ans. Yes, this can happen when the several acting on an object produces a zero resultant force.

***Q.20) Find the energy in kW h consumed in 10 hours by four devices of power 500 W each.***

Ans. Power = $\frac{\text{Energy}}{\text{Time}}$

Energy used by one device is

Energy = Power x Time

= (500 W) x (10 h)

= 5000 Wh

= 5 kWh

Energy used by four devices = 5 x 4 = 20 kWh

***Q.21) A freely falling object eventually stops on reaching the ground. What happens to its kinetic energy?***

Ans. The kinetic energy is converted into heat and sound energy.

# Lesson No.6
# Sound

*Textual Questions*

**Q1: How does the sound produced by a vibrating object in a medium reach your ear?**

Ans:- Sound is always produced by a vibrating object. The vibrating object produces a series of compressions and rarefactions in the medium. These pulses travel one behind the other as the sound wave. The sound wave on reaching our ear forces the tympanic membrane to vibrate and thus causing the sensation of hearing.

**Q2: Explain how sound is produced by your school bell?**

Ans:- When a school bell is hit by a hammer, it begins to vibrate and hence sound is produced.

**Q3: Why are sound waves called mechanical waves?**

Ans:- Sound waves are called mechanical waves because they need a material medium (like solid, liquid or gas) for their propagation.

**Q4: Suppose you & your friend are on the moon. Will you be able to hear any sound produced by your friend?**

Ans:- No, sound can't be heard directly on the surface of moon because there is no air on the moon to carry the sound wave.

**Q5: Which wave property determines**

**a) Loudness**

**b) Pitch**

Ans:- Loudness is basically determined by Amplitude. Whereas pitch is determined by the frequency wave.

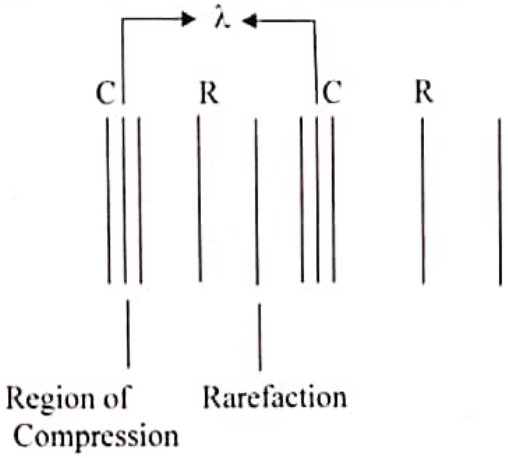
**Q6: Guess which sound has higher pitch:**
**Guitar or Car horn?**

Ans:- The sound of guitar is shriller (very high and loud) than that of a car horn. So, the sound of a guitar has a higher pitch.

**Q7: What are wavelength, frequency, time period and amplitude of a sound wave?**

Ans:-

a) Wave length:- The distance between two consecutive compressions (C)or two consecutive rarefactions (R) in a longitudinal wave (sound wave) is called the wave length. It is usually represented by greek letter lambda (λ). Its S.I unit is metre (m).




b) Frequency:- The number of oscillations per unit time is known as frequency of the sound wave. It is denoted by the Greek letter, nu (υ). Its SI unit is hertz (Hz)

c) Time period:- The time taken to complete one oscillation is known as time period. It is denoted by 'T'. Its SI unit is second (S).

d) Amplitude (A):- The maximum displacement of the particles of the medium from their original undisturbed positions, when a wave passes through the medium, is called the amplitude of the wave. Its SI unit is metre (m).

**Q8: How are wavelength and frequency of a sound wave related to its speed?**

Ans:-

Speed $v = \frac{\text{distance}}{\text{Time}}$

$= \frac{\lambda}{T}$ $= 1/T \times \lambda$

λ is wave length of sound. It is the distance travelled by the sound wave in one Time Period (T)

of the wave

$\therefore V = \upsilon \lambda$ $1/T = \lambda$

i.e speed = wave length x Frequency

**Q: Calculate the wavelength of a sound wave whose frequency is 220Hz and speed is 440m/s in a given medium?**

Ans:- We know that, $V=8 \times \upsilon$

Here V = 440m/s

ν=220Hz

$\therefore$ $440=8 \times 220$

or $\lambda \times 220 = 440$

or $\lambda = \frac{440}{220}$

or $\lambda = \frac{44}{}$

22

Or $\lambda = 2m$ therefore wavelength $\lambda$ is 2 m

**Q10: A person is listening to a tone of 500 Hz sitting at a distance of 450m from the source of the sound. What is the time interval between successive compressions from the source?**

Ans:- Time interval between two successive compressions,

$T = 1/\upsilon = 1/500 = 0.0025$

**Q11: In which of three media, air, water or iron, does sound travel the fastest at a particular temperature?**

Ans:- Sound travels fastest through iron with a speed of 5950m/s

**Q12: Distinguish between loudness and intensity of sound?**

Ans:- The amount of sound energy passing each second through unit area is called intensity of sound while as loudness is the measure of the response of the ear to the sound.

***Q13: An Echo is returned in 3S. What is the distance of the reflecting surface from the source, given that the speed of sound is 342 $ms^{-1}$***

**Ans:-** Speed of sound is 342 $ms^{-1}$.

Time taken from hearing the echo = 3S

Distance traveled by the sound = VT= 342 × 3 = 1026 m.

In 3S, sound has to travel twice the distance between the reflecting surface as the source.

Therefore, distance of the reflecting surface from the source = 1026/2 = 513 m

***Q14: Why are the ceilings of the concert halls curved?***

**Ans:-** The ceilings of the concert halls are curved so that sound after reflection reaches all corners of the hall.

***Q15: What is the audible ranges of the average human ear?***

**Ans:-** The audible range of the average human ear is 20 Hz to 20,000 Hz.

***Q16: What is the range of frequencies associated with?***

***a) Infrasound***

***b) Ultrasound***

**Ans:-** a) Range of frequency of Infrasound is less than 20 Hz.

b) Range of frequency of ultrasound is higher than 20Kz.

***Q17: A submarine emits a sonar pulse, which returns from an underwater cliff 1.02S. If the speed of sound in salt water is 1531$ms^{-1}$, how far away is the cliff?***

**Ans:-** Time between transmission and detection of sonar pulse, t = 1.02 S

Speed of sound in salt water, V=153$ms^{-1}$

Distance of the cliff = d (say)

Then, distance traveled by sound = 2d

So, 2d = speed x time = VT

$= 1531 \times 1.02$

or $d = 153 \times 1.02/2$

or d = 780.81 m

**Additional questions:**

***Q1: What is sound and how is it produced?***

**Ans:-** Sound is a form of energy and it is produced due to vibrations of different types of object, e.g, a vibrating tuning fork, a bell, wires of a sitar and a violin etc.

*Q2: Describe with the help of a diagram, how compressions and rarefactions are produced in air near a source of sound?*

**Ans:-** When a longitudinal wave travels in a medium, then the particles of the medium vibrate back and forth in the same direction in which the wave travels. When the vibrating particles come closer to one another than they normally are, then there is a momentary reduction in volume, increase in the density & pressure of the medium and a compression is formed. On the other hand, when the vibrating particles move further apart form one another than they normally are, then there is a momentary increase in volume, decrease in the density & pressure & a rarefaction is formed.

**Figure (consult sub. Teacher)**

*Q3: Demonstrate an experiment to show that sound needs a material medium for its propagation?*

**Ans:-** A material medium is necessary for transmitting sound. This can be shown by the following experiment.

An electric bell is suspended by rubber bands $RR^1$ in air-tight glass vessel V called bell jar. The bell jar is connected to a vacuum pump to remove the air. Initially, the bell jar is full of air. On pressing the switch, the bell starts ringing & its sound can be heard clearly. Thus, when air is present as the medium in the bell jar, sound can travel through it.

We now pump out the air from the bell jar gradually by switching on the vacuum pump attached to it. the sound of the ringing bell becomes fainter and fainter & ultimately diminishes. It is clear from this experiment that sound needs a material medium to travel.

**Figure (consult subject teacher)**

*Q4: Why is sound wave called a longitudinal wave?*

**Ans:-** A sound wave is called longitudinal wave as it travels in a medium in the form of compressions and rarefactions where the particles of the medium vibrate in a direction which is parallel to the direction of propagation of the sound wave.

*Q5: Which characteristic of the sound helps you to identify your friend by his voice while sitting with others in a dark room?*

**Ans;-** The quality (or timbre) of sound is that characteristic which enables us to distinguish one sound from the other even when these are of the same pitch & loudness. Each person has its own quality of sound & it is this characteristic which enables us to identify a person from others even without looking at him.

*Q6: Flash and thunder are produced simultaneously, but the thunder is heard a few seconds after the flash is seen, why?*

**Ans:-** The speed of light (c) is greater than the speed of sound (V) by a factor of the $10^6$. As $C/V = 3\times10^8 m/s / 340 m/s = 10^6$ thus, the flash of light is seen earlier than the thunder of sound even though both are produced simultaneously.

*Q7: A person has a hearing range from 20Hz to 20 KHz. What are the typical wavelength of sound waves in air corresponding to these two frequencing? Take the speed of sound in air as 34.4ms$^{-1}$?*

**Ans:-** Here $\nu_1$=20Hz and $\nu_2$=20KHz = $20 \times 10^3$ Hz.

Speed of sound, $V = 340 ms^{-1}$

Therefore $\lambda_1 = v/\nu_1 = 340/20 = 17.2m$

& $\lambda_2 = v/\nu_2 = 340/ 20\times10^3 = 0.0172m$

***Q8:*** ***Two children are at opposite ends of an aluminum rod. One strikes the end of the rod with a stone. Find the ratio of time taken by the sound wave in air and in aluminum to reach the send child.***

**Ans:-** Speed of sound is air = $340ms^{-1}$

Speed of sound in Aluminum = $6420ms^{-1}$

Since time taken by sound to travel a given distance in a medium is inversely proportional to its speed in that medium.

Now, Let 'x' be the length of the aluminum rod and let '$t_1$' and '$t_2$' are time intervals taken by sound to reach opposite ends via aluminum rod and air respectively.

Then $t_1 = x/6420$

And $t_2 = x/340$

$\therefore$ Ratio of time intervals $\frac{t_2}{t_1} = \frac{x/340}{x/6420}$ see

$= 18.55$ see.

***Q9:*** ***Does sound follow the same laws of reflection as light does? Explain?***

**Ans:-** Like light waves, sound waves also get reflected when these fall on the surface of an obstacle. The following simple experiment establishes that reflection of sound follows the same laws as those for reflection of light.

i) Place a large plane board, AB (of a metal, cardboard or wood) in the vertical position.

ii) Take two hollow metallic tubes P & Q (each about 1m long and about 8 – 10 cm in diameter)
and place them in the plane of the paper and in positions inclined to the board as shown in **Figure(consult sub. Teacher)**

iii) Hold a small watch 'w' at the free end of the tube P & try to hear the ticking sound of the watch by positioning the ear at E.

iv) Put a card board screen S in between the two tubes so that the sound produced by the watch does not reach the ear directly.

v) Turn the tube Q till the ticking sound of the clock is the loudest. In this position, it is found that the tubes are inclined to S at the same angle, i.e, i=r.

vi) The normal OS ot the surface lies in the same plane as that in which the incident & reflected sound wave lie.

From this experiment, we obtain the following two laws for the reflection of sound waves. These laws are as follows

a. The angle of reflection (r) is always equal to the angle of incidence (i) i.e, $\angle r = \angle i$.
b. The incident wave, the reflected wave and the normal (at the point of incidence), all lie in the same plane.

***Q11:*** ***When a sound is reflected from a distant object, an echo is produced. Let the distance between the reflecting surface and the source of sound production remain the same. Do you hear echo on a hotter day?***

**Ans:-** The minimum distance (d) for the distinct echo to be heard (say at $27^0$C) is 17.2m (therefore, 2d= vt=344 x 0.1 = 34.4m). On a hotter day, the temperature increases & the speed of sound in air also increases e.g, at $40^0$C, speed of sound, i.e, v=356 m/s & as such 2d=356x0.1 =35.6m or d=17.8m. thus, if distance of the reflecting surface and the source of

sound remains the same (i.e, 172m), no echo is heard on the hotter day as the minimum distance now required is 17.8m.

**Q12: Give two practical application of reflection of sound waves.**

1. **Megaphone**:- Sometimes we want a given sound to travel a large distance before it becomes inaudible. This can be done if we avoid the wastage of sound energy by its transmission in all directions. We, therefore, confine the sound waves with the help of a speaking tube or a megaphone so that they travel in a particular direction. Sound waves which are now confined in a particular region by their multiple reflections from the walls of the tube, travel larger distance than without the help of the tube.

**Figure (consult sub. Teacher)**

**Ear Trumpet:-** It is a sort of machine used by persons who are hard of hearing. The sound energy received by the wide end of the trumpet is concentrated into a much smaller area at the narrow end by multiple reflections, which makes the inaudible sound audible to the user.

***Q13: A stone is dropped from the top of a tower 500m high into a pond of water at the base of tower. When is the splash heard at the top? Given, $g=10ms^{-2}$ & speed $=340ms^{-1}$.***

**Soln:** Here , height through which the stone falls, h =500m

Speed of sound, v=340m/s, $g=10m/s^2$

If t is the time taken by the stone to fall through h, then

$h = \frac{1}{2} gt2 \quad \Rightarrow t = \sqrt{2h/g}$

therefore $t=\sqrt{2}\times500/10 = 10S.$

further, if $t'$ is the time taken by sound to travel to the top of the tower,

$t' = h/v = 500/340 = 1.47s$

therefore time after which the splash is heard at the top of the tower =t +

$t'=10S+1.47s=11.47s$

***Q14: A sound wave travels at a speed of $339ms^{-1}$. If its wavelength is 1.5cm, what is the frequency of the wave? Will it be audible?***

**Ans:-** Here, speed of sound wave, V=339m/s

Wavelength of sound wave, $8=1.5cm = 1.5\times10^{-2}m$

Therefore frequency of the sound wave, $v=v/8 = 339/1.5\times10^{-2} =22600$ Hz.

The sound is not audible as its frequency lies beyond the audible range (20Hz – 20,00Hz)

***Q15: What is reverberation? How can it be reduced?***

**Ans:-** The phenomenon of persistence or prolongation of audible sound after the source has stooped emitting sound is called reverberation.

Since reverberation is due to repeated reflections of sound waves from the ceiling, floor, walls, etc. of a hall or an auditorium; we can reduce reverlation by increasing the absorption of sound energy as:

i) The walls are covered with some sound absorbing material like felt, fibreboard, etc. or by heavy curtains with folds.

ii) The floor is carpeted.

iii) The furniture is upholstered.

iv) False ceiling of a suitable sound absorbing material is used.

***Q16: What is loudness of sound? What factors does it depend on?***

**Ans:-** The sensation produced in the ear which enables us to distinguish between a loud and a faint sound is called loudness. The loudness depends upon:

i) The amplitude of the wave.

ii) The surface area of the vibrating body.
iii) The density of the medium, etc.

***Q17: Explain how bats use ultrasound to catch a prey?***

**Ans:-** The ultrasonic waves emitted by the bat are reflected from the prey (e.g. an insect) & are detected by its ear. The nature of reflected waves tells the bat:
i) the location and ii) the nature of its prey.

***Q18: How is ultrasound used for cleaning?***

**Ans:-** The object to be cleaned is placed in a cleaning solution. When ultrasonic waves are passed through the solution, due to their high frequency, particles of dirt, dust and grease get detached even from the unreachable portions of the object & drop out in the solution.

***Q19: Explain the working and application of a SONAR?***

**Ans;-** A sonar is a device which measures the distance, direction and speed of objects lying under water using ultrasonic waves.

A sonar which is installed in a ship or a boat, consists of i) a transmitter & ii) a detector. The ultrasonic waves produced by the transmitter travel through water. After getting reflected by the object on the seabed, these waves are picked up by the detector. The detector converts the reflected ultrasonic waves into electrical signals which are properly recorded.

The sonar technique is used to:

i) Determine depth of the sea, called echo depth ranging.
ii) Locate under water hills, valleys, icebergs, sunken-ships.
iii) To locate the position of other ships or submarines, ship-to-ship communication also uses ultrasonic waves.

***Q20: A sonar device on a submarine sends out a signal & receives an echo 5s later. Calculate the* speed of sound in water if the distance of the object form the submarine is 3625m.**

**Soln:**

Here, time interval between the transmission of the signal and its reception, t =5s.
Distance of the object from the submarine, d=3625m
If v is the speed of sound in water, then
$2d=vt$ or $v=2d/t = 2\times3625/5 =1450m/s$

***Q21: Explain how objects in a metal block can be detected using ultrasound?***

**Ans:-** Metal blocks used in the construction of buildings, bridges, machines and scientific equipment cracks & holes within the blocks, which are invisible from outside, reduce the strength of a structure. To detect these flaws, ultrasonic waves are passed through the metal block. Transmitted waves are detected by detectors. Where as ultrasonic waves pass through the flawless portions of the block, these are reflected back by even a minor defect & do not reach the detector.

**Figure (consult sub. Teacher)**

**Q22: Explain how the human ear works?**

Ans:- The human ear works by the following five step sequential procedure:

i) The outer ear collects sound waves which are conducted through the auditory canal.
ii) These waves fall on the ear drum & set it into vibrations.
iii) The middle ear consists of three ear ossicles; hammer, anvil & stirrup, amplifies these oscillations about 60 times.

iv) The inner ear which contains cochlea & is filled with a fluid converts these pressure variations into electrical signals.

v) These electrical signals are conveyed to the brain via auditory nerve for interpretation.

**Additional Questions:-**

*Q1: What is a Sonic Boom?*

**Ans:-** It is an explosive noise caused by the shock waves from an aircraft or any other object which is traveling faster than the speed of sound.

*Q2: What is the difference between an echo & a reverberation?*

**Ans:-** An echo is formed when sound reflected due to strong reflection comes back after an interval of 0.1S or more. In an echo, the original & reflected sounds are heard separately. Reverberation, on the other hand, consists of successive reflections which follow each other so quickly that these cannot produce separate echoes.

**→ Relation between time-period and frequency of Wave?**

The time required to produce one complete wave is called time-period of the wave. Suppose the time period of a wave is T-seconds.

Now, in T seconds, no. of waves produced=1 so, in 1 second, no. of waves produced will be =1/T but the no. of waves produced in 1 second is called its frequency. So, the frequency of a wave is the reciprocal of its time-period i.e.,

Frequency = 1/Time period

or $n = 1/T$

Where n = frequency of the wave

and T = Time – period of the wave.

**Problem 1→** *What is the frequency of a sound wave whose time period is 0.05 Sec?*

**Solution:-** The relationship between the frequency and time – period of a wave is:

$\upsilon = 1/T$

Here, $\upsilon$ =? (to be calculated), T=0.05 Sec.

Putting this value in above relation, we get;

$\upsilon=1/0.5 \Rightarrow \upsilon=100/5 \Rightarrow \upsilon=20$ Hz.

Thus, the frequency of the sound wave is 20 Hz.

**Problem →** *The wavelength of sound emitted by a source is 1.7 x $10^{-2}$m. Calculate the frequency of the sound, if its velocity is 343.4ms$^{-1}$?*

**Solution:-** We know that, $V = \upsilon \times \lambda$

Here, $V = 342.4 ms^{-1}$

$\upsilon$=? (to be calculated)

$8=1.7\times10^{-2}$m

So, putting these values in above relation, we get:

$343.4=f \times 1.7\times10^{-2}$

$\upsilon= 343.4/1.7\times10^{-2}$

$\upsilon=3434\times10^{2}/17$

$\upsilon=202\times10^{2}$Hz

**Problem:-** *A sound wave has a frequency 1000 Hz and wavelength 34cm. How long will it take to move through 1km?*

**Solution:-** Here, frequency of wave, $\nu$=1000 Hz.

Wavelength of the wave, 8=34cm =0.34m

Speed of sound wave, V = v8

V=1000×0.34 = 340m/s

Therefore time taken by the wave to move through 1 km (i.e, 1000m), i.e

T=D/S = 1000m/340m/s = 2.94s.

**Problem:-** *A boy hears an echo of his own voice from a distant hill after 1s. the speed of sound is 340m/s. what is the distance of the hill from the boy?*

**Soln:-** Here, speed of sound, V=340m/s

Time taken for haring the echo, t=1s

→ if 'd' is the distance between the hill and the boy.

Then, total distance travelled by the sound in going & coming back =2d

As distance travelled by sound = speed x time, 2d=vt

or d=vt/2 = 340×1/2

= d = 170m.

**Problem:-** *It takes 2.45 to record the echo of a sonar. If the velocity of sound in water is 1450m/s, find the depth of the ocean floor?*

**Soln:-** Here, t=2.45, v=1450 m/s

Therefore depth of the ocean floor, d=vt/2 $d=\frac{1450\times2.4}{2}$ = 1740m

**Problem:-** *The audible range of a human ear is 20Hz to 20KHz. Convert this into corresponding wavelength range. The speed of sound at ordinary temperature is 340m/s*

**Soln:-** Here, speed of sound in air, V=340m/s

Lowest frequency, $\nu_1$=20Hz

Highest frequency, $\nu_2$ =20KHz = $20\times10^3$ Hz

Clearly, upper limit of wavelength, i.e.

$8_1 = V/\nu_1 = 340/20 = 17m$

and lower limit of wavelength, i.e.,

$8_2 = V/\nu_2 = 340/20\times10^3 = 0.017m$.

Thus, the audible wavelength range is 0.017 to 17m.