$v = \omega\sqrt{r^2 - 0^2}$

$= \omega\sqrt{r^2}$

$= \omega r$ =so velocity is maximum in this case. ***so important***

Simple Pendulum

23. Heavy mass suspended by a light string of length "l" with upper end attached.
24. The length of pendulum is sum of legth of the strong plus the radius of metallic bob.
25. The displacement should be small because for small θ = → $\sin\theta = \theta$
26. The tention of the string cancelled with x-somponent of weight.
27. The y-componet of tention is force that cause simple harmonic motion.

Time Period:

28. $T = 2\pi/\omega$ putting $\omega = \sqrt{g/l}$

→ $T = 2\pi/\sqrt{g/l}$

→ $T = 2\pi\sqrt{\frac{l}{g}}$

Here

29. T= time period
30. L = length of the string
31. G = ravitational force

Equation Shows that;

32. Time period is directly proportional to the length of radius, greater the length of pendulum, greater will be the time period.
33. The time period is inversely proportional to the gravity. Greater the value of g, smaller the value of time period.
34. Tim period of simple pendulum is independent to the mass of pendulum, wheather you attaced 100 Kg bike or 1 Kg stone, it will take same time to complete one revolution.

Proof that simple pendulum is SHM

- $F_{applied} = -F_{restoring}$
- $ma_- = w_y$
- $ma = -mg\sin\theta$
- $a = -g\sin\theta$ for small angle $\sin\theta = \theta$
- $a = -g\theta$ where $\theta = x/l$
- $a = -(g/l)x$ where $g/l = x^2$ = constant
- $a \propto -x$

ω for

- pendulum = $\sqrt{\frac{g}{l}}$
- mass spring system = $\sqrt{\frac{k}{m}}$

MCQs FOR ETEA

35. The ratio of time period of mass one kg to that of mass 100 kG when length and g is constant ?

→→ Its is 1:1 or same because time period is independent to mass.

---

36. The ratio of time period of mass on earth to that of moon?

→→ on moon $g_{moon} = g_{earth}/6$ to time period will be

$T = 2\pi\sqrt{\frac{l}{\frac{g}{6}}}$

$\rightarrow T = 2\pi\sqrt{\frac{6l}{g}}$

$\rightarrow T = \sqrt{6} \times 2\pi\sqrt{\frac{l}{g}}$

$= \sqrt{6}\,T$, so on moon time period incrase because g value decrease.

37. As IN earth and moon, moon have less value of g, so time period is more as compare to earth.

38. As on Karachi and moon, where muree is on height and its value of g is less than Karachi so time period onmuree mountains is more than as compare to Karachi.

39. If lenth is increase 4 times then time period will be

$\rightarrow T = 2\pi\sqrt{\frac{4l}{g}}$

$T = 2 \times 2\pi\sqrt{\frac{l}{g}} = 2T$

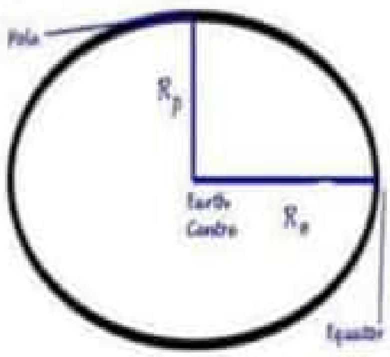
If lenth is increaseis 4 time, the time period will bomes double like $1\rightarrow2$, $2\rightarrow4$, $3\rightarrow6$, $4\rightarrow8$ and so on

40. At centre of earth as value of g is zero, so time perio will be

$T = 2\pi\sqrt{\frac{l}{g}}$

$\rightarrow T = 2\pi\sqrt{\frac{l}{0}}$

$\rightarrow T = 2\pi(0) = 0$



41. The time period will be greater for pendulum at pole or equator or same for both of these.

$\rightarrow\rightarrow$ The value of g is inversely proportional to the distance from the centre of the earth so $g_{pole} > g_{equator}$

So $T_{pole} < T_{equator}$

42. If the value of length and g both becomes double then the T will be ;

$\rightarrow$ $T = 2\pi\sqrt{\frac{l}{g}}$

$\rightarrow T = 2\pi\sqrt{\frac{2l}{2g}}$

$T = 2\pi\sqrt{\frac{l}{g}} = T$, the time period will be same .

43. The ratio of timeperiod of a pendulum of length ratio $L_1 : L_2$.

$\rightarrow$ $T = [2\pi\sqrt{\frac{L1}{g}}\,] / [\,2\pi\sqrt{\frac{L2}{g}}]$

$\rightarrow \sqrt{\frac{L1}{g}}\,] / \sqrt{\frac{L2}{g}}$

$= L_1 / L_2$, the ratio of time period will be same as length because timeperiod is directly proportional to the length.

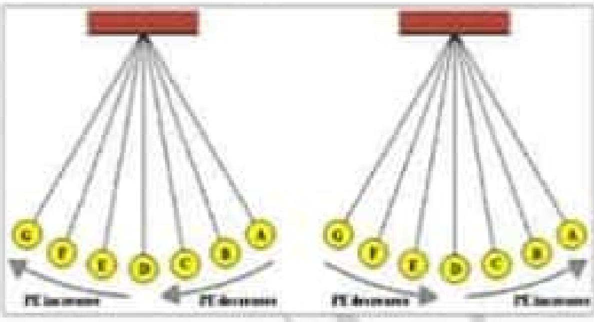
Energy Conservatioin in SHM

44. Law of conservation energy is totally conserved in case of S.H.M.

Potential energy:

45. P.E = W= F_{av} x = 1/2k x_0 $x_0 = \frac{1}{2}kx_0^2$ this is PE at extreme position
46. For any position(x) then P.E $=\frac{1}{2}kx^2$

so important



47. As potential energy is directly proportional the distance from the mean position, so maximum the distance, as in case of amplitude, masimum will be the potential energy.

Case-1:

48. potential energy at means position where x= 0 then P.E $=\frac{1}{2}kx^2=\frac{1}{2}k(0)^2 = 0$ ***so important***

Case-2:

49. Potential energy at extreme x = x_0 = amplitude = P.E$=\frac{1}{2}kx_0^2$

so important

Kinetic Energy

50. K.E = 1/2 mv^2

$= 1/2\ m\,(\omega\sqrt{r^2-x^2})^2$

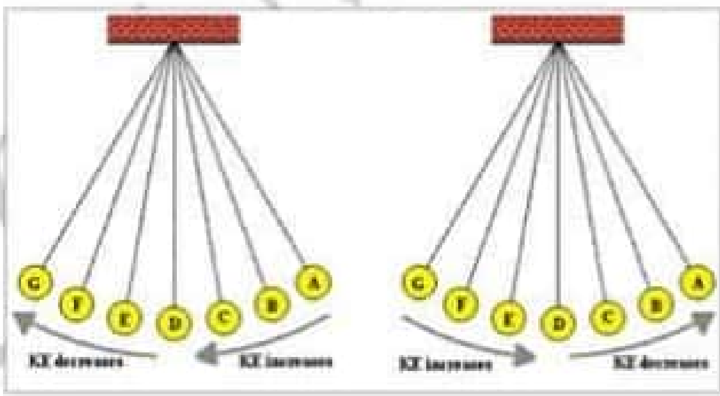
$= 1/2\ m\,(\sqrt{k/m}\,\sqrt{r^2-x^2})^2$

$=1/2\ m\,(k/m\ \ r^2-x^2)$

$=\frac{1}{2}\,m\,(\frac{k}{m}\,(r^2-x^2))$

$=\frac{1}{2}\,k\,(r^2-x^2)$

$=\frac{1}{2}\,k\,(x_o^{\,2}-x^2)$



Case-1:

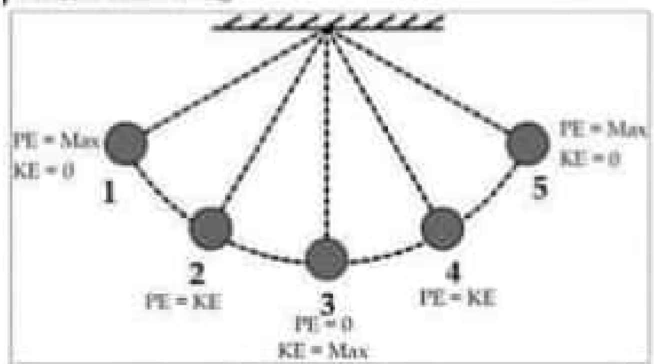
51. Whenethe object is at amplitudeor at etreme position then $x=x_0$

$\rightarrow$ K. E$=\frac{1}{2}\,k\,(x_o^{\,2}-x^2)$

$=\frac{1}{2}\,k\,(x_o^{\,2}-x_o^{\,2})$

$=\frac{1}{2}\,k(0) = 0$

Case-2



52. When object is at mean position
53. $K.E = \frac{1}{2}\,k\,(x_o^{\,2}-x^2)\ K$
54. $K.E = \frac{1}{2}\,k\,(x_o^{\,2}) \rightarrow$ maximum K.E

Total energy

55. Total energy = K.E + P.E

$= [\frac{1}{2} k (r^2 - x^2)] + [\frac{1}{2} kx^2]$

$\rightarrow \frac{1}{2} k[r^2 - x^2 + x^2]$

$= \frac{1}{2} kr^2$

$= \frac{1}{2} kx_o^2$

MCQs FOR ETEA

56. The energy of pendulum is contant or variable?

→→ The total energy depends upon the amplitude as the amplitude remains constant so the energy also remains constant.

57. By doubling the amplitude the energy will increase, decrease or remains constant

→→ Energy is directly proportional to the square of amplitude so doubling the amplitude wil increase the energy times. ***so important***

58. The energy was 4 energy unit if amplitude is increase by 3 times, the new energy will be;

→ $T.E = \frac{1}{2} kx_o^2$

$= \frac{1}{2} k(3x_o)^2$

$= 9 x \frac{1}{2} kx_o^2$

= 9 T.E = 9 x 4 = 36 energy units.

59. The total energy ratio if amplitude ratio is 1: 2

a)4:1 b)1:4

c)1:9 d)9:1

ans: b

solution → $\frac{1}{2} k1^2 / \frac{1}{2} k2^2$

→ $\frac{1}{2} k /4 \ \frac{1}{2} k = 1:4$

60. The total energy ratio if amplitude ratio is 1: 3

a)4:1 b)1:4

c)1:9 d)9:1

ans: c

solution: → $\frac{1}{2} k1^2 / \frac{1}{2} k3^2$

→ $\frac{1}{2} k /9 \ \frac{1}{2} k = 1:9$

61. The point where K.E is equal to Potential energy: ***so important***

a) $x = a/\sqrt{\frac{2}{3}}$ b) $x = \frac{a}{\sqrt{2}}$

c) $x = \frac{a}{\sqrt{3}}$ d) $x = \frac{a}{\sqrt{4}} = \frac{a}{2}$

e) $x = a/\sqrt{\frac{2}{3}}$

ans: b

solution: → K.E = P.E

$\rightarrow \frac{1}{2} k (r^2 - x^2) = \frac{1}{2} kx^2$

$\rightarrow (r^2 - x^2) = x^2$

$\rightarrow r^2 = x^2 + x^2$

$\rightarrow r^2 = 2x^2$

$\rightarrow x^2 = r^2/2$

$\rightarrow x = \sqrt{r^2/2}$

$\rightarrow x = r/\sqrt{2}$

$x = a/\sqrt{2}$ where x is displacemt and a is amplitude

---

62. The point where K.E is double of P.E

a) $x = a/\sqrt{\frac{2}{3}}$ b) $x = \frac{a}{\sqrt{2}}$

c) $x = \frac{a}{\sqrt{3}}$ d) $x = \frac{a}{\sqrt{4}} = \frac{a}{2}$

e) $x = a/\sqrt{\frac{2}{3}}$

ans: c

solution:

→→ K.E = 2P.E

$\rightarrow \frac{1}{2} k (r^2 - x^2) = 2 \frac{1}{2} kx^2$

$\rightarrow (r^2 - x^2) = 2 x^2$

$\rightarrow r^2 = x^2 + 2x^2$

$\rightarrow r^2 = 3x^2$

$\rightarrow x^2 = r^2/3$

$\rightarrow x = \sqrt{r^2/3}$

$\rightarrow x = r/\sqrt{3} = x = a/\sqrt{3}$

---

63. The point where K.E is triple of potential energy

a) $x = a/\sqrt{\frac{2}{3}}$ b) $x = \frac{a}{\sqrt{2}}$

c) $x = \frac{a}{\sqrt{3}}$ d) $x = \frac{a}{\sqrt{4}} = \frac{a}{2}$

e) $x = a/\sqrt{\frac{2}{3}}$

ans: d

solution:

→→ K.E = 3 P.E

$\rightarrow \frac{1}{2} k (r^2 - x^2) = 3 \frac{1}{2} kx^2$

$\rightarrow (r^2 - x^2) = 3x^2$

$\rightarrow r^2 = 3x^2 + x^2$

$\rightarrow r^2 = 4x^2$

$\rightarrow x^2 = r^2/4$

$\rightarrow x = \sqrt{\frac{r^2}{4}}$

$\rightarrow x = r/\sqrt{4} = x = a/2$ ***so important***

---

64. The point where P.E is double of K.E

a) $x = a/\sqrt{\frac{2}{3}}$ b) $x = \frac{a}{\sqrt{2}}$

c) $x = \frac{a}{\sqrt{3}}$ d) $x = \frac{a}{\sqrt{4}} = \frac{a}{2}$

e) $x = a/\sqrt{\frac{2}{3}}$

ans: e

solution: →→ 2K.E = P.E

$\rightarrow 2 \frac{1}{2} k (r^2 - x^2) = \frac{1}{2} kx^2$

$\rightarrow (2r^2 - 2x^2) = x^2$

$\rightarrow 2r^2 = x^2 + 2x^2$

$\rightarrow 2r^2 = 3x^2$

$\rightarrow x^2 = 2r^2/3$

$\rightarrow x = \sqrt{2r^2/3}$

$\rightarrow x = r/\sqrt{2/3}$

$= x = a/\sqrt{\frac{2}{3}}$ ***so important***

important

- ✓ K.E = P.E

  $x = \frac{a}{\sqrt{2}}$
- ✓ K.E = 2P.E

  $x = \frac{a}{\sqrt{3}}$
- ✓ K.E = 3P.E

  $x = \frac{a}{\sqrt{4}} = \frac{a}{2}$
- ✓ P.E = 2 K.E

  a) $x = a/\sqrt{\frac{2}{3}}$ b) $x = \frac{a}{\sqrt{2}}$

c) $x = \frac{a}{\sqrt{3}}$ d) $x = \frac{a}{\sqrt{4}} = \frac{a}{2}$

e) $x = a/\sqrt{\frac{2}{3}}$

ans:

solution:

Free and force oscillation

65. A body is said to be eexecuting free vibrations if it oscillates with its natural frequency without the interference of an external force. Examples : simple pendulum
66. If a freely oscillating syste is subjected to an external force, then forced vibrations will take place. Example; vibration of factory floor due to machinary

Resonance

67. A marked inceease in ampltidue of a vibration body when an external force having a time period equal to the natural timer period of a body is apllied to it. Tis process is called resonance.

Examples of resonace *****so important*****

68. Radio: when two frequecnies match, energy absorption is maximum.
    An example of electrical resonance.
69. Magnetic Resonance image
70. Microwave oven

Phase

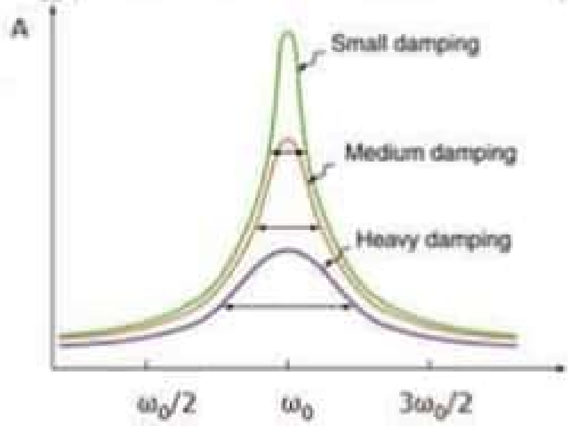
71. $x = x_0 \cos(\omega t + \phi)$
    where $\theta = \omega t + \phi$ is the phase angle
    ϕ gives information regarding initial or starting point.
72. gerneal equation of S.H.M $x = x_0 \cos \omega t$
73. The $\theta = \omega t$ which specifies the displacement as well as te directin of motion of the point oscillating S.H.M is called phase.

Damped Oscillation

74. Oscillation where amplitude becomes smaller and smaller with time are known as damped oscilation.
75. The process by which the energy of the oscilating system is dissipated is known as damping.
76. The amplitude of an oscillating system decreasing gradually with time till it become zero, such osicllations,in which the amplitude decrease steadily with time , are called damped oscillations.

Sharpeness of resonance

77. At resoncane,The amplitude of vibrations becomes very large when damping is small.
78. Damping prevents the amplitude from becoming very large.



79. Damping is inversely proportional the amplitude.

MCQs FOR ETEA

1. When a particle execute repeated movement about a mean position, it is Harmonic motion
2. If a motion is repeated at regular intervals, it is called Periodic motion
3. The number of vibration completed by a body in one second is called Frequency
4. The unit of frequency is Hertz / 1Hz / 1cs-1 / cps
5. The number of revolution per second of a body is called Angular frequency
6. (ω=2πf)
7. In S.H.M the negative sign shows that both acceleration and displacement are Oppositely directed
8. Length of string + length of radius of metallic bob = Length of simple pendulum
9. The longer the pendulum the greater will be its Time period
10. The time period of simple pendulum is independent to the Mass of the bob
11. At extreme position K.E is Zero
12. At mean position K.E is Maximum
13. At extreme position the P.E is Maximum
14. At mean position the P.E is Zero
15. Law of conservation of energy is conserved in case of S.H.M
16. The angle θ= ωt which specifies the displacement x as well as the direction of the motion of the point oscillating S.H.M is called Phase
17. Oscillations where amplitude becomes smaller and smaller with time are called Damped oscillations
18. If the length of simple pendulum becomes fore times, its time period will become Two times
19. To find time period of simple pendulum we keep amplitude Small
20. Time period of simple pendulum is one second its length is 0.25 m
21. When the length of simple pendulum is increased four times, the frequency of its oscillation will Half
22. If the length of simple pendulum is halved and mass is doubled then its time period Decreased by 4
23. Elastic collision involves No gain no loss of energy
24. If tunnel is bored through center of earth and stone is dropped it will Simple harmonic motion
25. The SI unit of spring constant (k) is identical to Surface tension

For ETEA

1. **Is every oscillatory motion simple harmonic? Give examples.**	**Ans.** No, it is not necessary for an oscillatory motion to be simple harmonic. In oscillatory motion a body moves to and fro about a fixed point

periodically. E.g. the motion of tuning fork, swing etc. While for SHM, the following two conditions must be satisfied.

a. The acceleration of the vibrating body is directly proportional to the displacement from the mean position at any instant, and
b. The acceleration is always directed towards the mean position. For example
   i. Vibratory motion of simple pendulum.
   ii. Vibratory motion of a mass spring system

It is to be noted that every SHM is oscillatory but every oscillatory motion is not necessary a SHM.

2. For a particle with simple harmonic motion, at what point of the motion does the velocity attain maximum magnitude? Minimum magnitude?

Ans. For a particle executing SHM its total energy at any instant of time is constant. That is the sum of K.E and P.E remains the same all the time. Since K.E of the particle passing through mean position is maximum (Equal to total energy) so at this position the velocity of the particle will be maximum. When the particle is at either position, the total energy of the particle is in the form of P.E and its K.E is equal to zero. As K.E is zero at other extreme position, so the velocity of the particle is also zero at these positions.

3. Is the restoring force on a mass attached to spring in simple harmonic motion ever zero? If so, where?

Ans. Yes, the restoring force in SHM becomes zero at the mean position. According to Hook's law we have

$F = -Kx$ ------------1

In equation 1 "x" represents the displacement of vibrating body from mean position.

Now at the mean position, we have $x = 0$

So equation 1 becomes

$F = -K(0) \rightarrow F = 0$ -------------- 2

Equation 2 shows that the restoring force is zero at the mean position.

4. If we shorten the string of a pendulum to half to its original length, what is the affect on its time period and frequency?

Ans. <u>Effect on time period:</u>

We know that time period of simple pendulum is given by,

$$T = 2\pi\sqrt{\frac{l}{g}} \text{ ------------------ } 1$$

Now if the length becomes half then we put $l = \frac{l}{2}$ in equation 1 we get

$$T = 2\pi\sqrt{\frac{l}{2g}}$$

$$T = \frac{1}{\sqrt{2}}\,[2\pi\sqrt{\frac{l}{2g}}] \text{ --------------- } 2$$

Putting the equation 1 in equation 2 we get,

$$T = \frac{T}{\sqrt{2}} \text{ ----------- } 3$$

Equation 3 shows that the time period will decrease by a factor is $\frac{1}{\sqrt{2}}$ when the length of the string becomes half.

<u>Effect on frequency:</u>

We know that

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}} \text{ ------------------- } 4$$

Put $l = \frac{l}{2}$ in equation 4 we get

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{(\frac{l}{2})}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{2g}{l}}$$

$$f = \sqrt{2}\left[\frac{1}{2\pi}\sqrt{\frac{g}{l}}\right] \text{ ------------------------ } 5$$

Putting equation 4 in equation 5 we get

$$f = \sqrt{2}f \text{ ------------------------ } 6$$

Equation 6 shows that frequency of simple pendulum will increase by a factor $\sqrt{2}$ when the length of the string becomes half.

5. Suppose you stand on a swing instead of sitting on it. Will your frequency of oscillation increase or decrease?

Ans. The swing may be considered as a simple pendulum. In this case the frequency of oscillation is given by,

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}} \text{ ________________ } 1$$

Where l = length the pendulum and is equal to the distance from the point of suspension to the center of gravity (Navel) of the person on the swing.

This length decreases as the person stands up on the swing i.e. center of gravity of the person rises up. Using equation 1 it is clear that frequency of oscillation is inversely proportional to the square root of length of the pendulum. So, frequency of oscillation increases as length decreases when the person stands up instead of sitting

For ETEA

6. Is every oscillatory motion simple harmonic? Give examples.

Ans. No, it is not necessary for an oscillatory motion to be simple harmonic. In oscillatory motion a body moves to and fro about a fixed point periodically. E.g. the motion of tuning fork, swing etc. While for SHM, the following two conditions must be satisfied.

c. The acceleration of the vibrating body is directly proportional to the displacement from the mean position at any instant, and
d. The acceleration is always directed towards the mean position. For example
   iii. Vibratory motion of simple pendulum.
   iv. Vibratory motion of a mass spring system

It is to be noted that every SHM is oscillatory but every oscillatory motion is not necessary a SHM.

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---

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Now if the length becomes half then we put $l = \frac{l}{2}$ in equation 1 we get

$$T = 2\pi\sqrt{\frac{l}{2g}}$$

$$T = \frac{1}{\sqrt{2}}\left[2\pi\sqrt{\frac{l}{2g}}\right] \text{ -------------- } 2$$

Putting the equation 1 in equation 2 we get,

$$T = \frac{T}{\sqrt{2}} \text{ ----------- } 3$$

Equation 3 shows that the time period will decrease by a factor is $\frac{1}{\sqrt{2}}$ when the length of the string becomes half.

<u>Effect on frequency:</u>

We know that

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}} \text{ ------------------- } 4$$

Put $l = \frac{l}{2}$ in equation 4 we get

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{(\frac{l}{2})}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{2g}{l}}$$

$$f = \sqrt{2}\left[\frac{1}{2\pi}\sqrt{\frac{g}{l}}\right] \text{ ----------------------- } 5$$

Putting equation 4 in equation 5 we get

$$f = \sqrt{2f} \text{ -------------------------- } 6$$

Equation 6 shows that frequency of simple pendulum will increase by a factor $\sqrt{2}$ when the length of the string becomes half.

---

10. Suppose you stand on a swing instead of sitting on it. Will your frequency of oscillation increase or decrease?

Ans. The swing may be considered as a simple pendulum. In this case the frequency of oscillation is given by,

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}} \text{ \_\_\_\_\_\_\_\_\_\_\_\_\_\_ } 1$$

Where l = length the pendulum and is equal to the distance from the point of suspension to the center of gravity (Navel) of the person on the swing.

This length decreases as the person stands up on the swing i.e. center of gravity of the person rises up. Using equation 1 it is clear that frequency of oscillation is inversely proportional to the square root of length of the pendulum. So, frequency of oscillation increases as length decreases when the

(11): what is the frequency of oscillation if the time period is 20ms?

Solution: Given data: Time period = T = 20ms = $20 \times 20 \times 10^{-3}$s [milli-$10^{-3}$]

Required: Frequency of oscillation = f =?

Calculation: We know that, $f = \frac{1}{T}$ ________ (1)

Putting the values in equation (1), we get

$f = \frac{1}{T} = \left[\frac{1}{20\times10}\right]$Hz

$f = 0.05\times10^{3}$ Hz = f = 50Hz

Answer: F = 50Hz

(12): when an object oscillates with a frequency of 0.5 Hz, what is its time period?

Solution:

Given data: Frequency= f = 0.5Hz

Required: Time period = T =?

Calculation: We know that, $f = \frac{1}{T}$ =$T= \frac{1}{f}$ ________ (1)

Putting the values in equation (1), we get

$T = \frac{1}{f} = = \frac{1}{0.5} = 2$ sec

Answer: T = 2sec

(13) A spring has a spring constant of 48.0N/m. this spring is pulled to a distance of 55cm from equilibrium. What is the restoring force ?

Solution: Given data: Displacement = x = 55cm = 0.55m,k = 48.0N/m

Required: restoring = F =?

Calculation: We know that, F= -kx ________ (1)

person stands up instead of sitting

Putting the values of equation (1), we get

= F = -48.0×0.55N = F = - 26.4 N

Answer: F - 26.4 N

(14) Determine the restoring force of a spring displaced 1.5m, with the spring constant of 30.0N/m.?

Solution: Given data: Displacement =x=1.5m, spring constant = k = 30.0N/m

Required: Restoring force = F =?

Calculation: We know that, F = -Kx________ (1)

Putting the values of equation (1), we get

F = -Kx = -30.0×1.5N = F = -45N

Answer: F - 45 N

(15) What is the mass of a vertical mass- spring system if it oscillates with a period of 2.0sec and has a spring constant of 20.0N/m?

Solution: Given data: Time period = T = 20 sec, spring constant = k = 20.0N/m

Required: Mass of vertical mass- spring system=m=?

Calculation: We know that,

$T= 2\pi\sqrt{\frac{m}{k}}$ ________ (1)

Squaring both sides of equation (i), we get,

$T^2= 4\pi^2 \frac{m}{k}$ = $m= \frac{T2K}{4\pi2}$ ________ (2)

Putting the value in equation (2), we get,

$m = \frac{(2)\times20}{4\times(3.14)} = 2.02$ kg

Answer: m 2kg

(16): A body of mass 0.2kg is attached to a spring placed on a frictionless horizontal surface. The spring constant of spring is 4 N/m. find the time period of oscillating mass-spring system.

Solution: Given data: Mass = m= 0.2kg, spring constant = k = 4N/m

Required: Time period = T =?

Calculation: We know that, T= $2\pi\sqrt{m/k}$ _________ (1)

Putting the value of equation (1), we get

T = $2\times3.14\sqrt{0.2/4} = 6.28\times\sqrt{0.05sec}$

T = 6.28×0.22sec = T = 1.38sec

Answer: T = 1.4sec

---

(17)Determine the magnitude of restoring force for a pendulum bob of mass 100.0gm that has been to an angle of 10^0 from the vertical.

Solution: Given data: Mass = m= 100gm, Acceleration due to gravity = g = 9.8m/sec^2

Angle = ɵ = 10^0

Required: Restoring force = F =?

Calculation: We know that, in case of simple pendulum, the component "mg sinɵ" acts as restoring force, so we have, F= - mg sinɵ _________ (1)

Putting the values of equation (1), we get

= F= -0.1×9.8× sin10^0 = - 0.98×0.17N

Answer: F= -0.167N

---

(18): At what angle must a pendulum be displaced to create as restoring force of 4.00N on a bob with a mass of 500gm?

Solution: Given data: Restoring force = F = 4.00N, Mass = m= 500gm=0.5kg

Required: Angle =ɵ=?

Calculation: We know that, in case of simple pendulum, the component "mg sinɵ" acts as restoring force, so we get, F= - mg sinɵ = sinɵ = F/mg _________ (1)

Putting the values of equation (1),we get

= sinɵ = 4.00/(0.5×9.8)= 4.00/4.9=0.816

= sinɵ = 0.816 = ɵ = $\sin^{-1}$ (0.816)= 54.6^0

Answer: ɵ = 54.6^0

---

(19): What is the gravitational field strength on planet mercury, if a 0.500 m pendulum swings with a solution of 2.30sec?

Solution: Given data: Time Period = T = 2.3 sec,

Length = l = 0.500 m

Required: Gravitational field strength = g=?

Calculation: we known that T = $2\pi\sqrt{\frac{l}{g}}$ --------------------- (1)

Squaring both sides of equation 1 we get

$$T^2 = 4\pi^2 l / g = \frac{4\pi^2 l}{T^2}$$ -------------------------- (2)

Putting the values of equation 2 we get

$$g = \frac{4\times(3.14)^2\times0.500}{(2.3)^2} = \frac{19.7}{5.29} = 3.73\,N/kg$$

Answer: g = 3.73 N/Kg

---

(20) What is the gravitational field strength at the top of Mount Everest at an altitude of 8954.0 m, if a pendulum with a length of 1.00m has a period of 2.01 sec?

Solution: Given Data: Length = l= 1m

Time period = T = 2.01 sec

Required: Gravitational field strength = g=?

We know that, T = $2\pi\sqrt{\frac{l}{g}}$ -------------------- (1)

Squaring both sides of equation (1)

$$T^2 = 4\pi^2 l / g = \frac{4\pi^2 l}{T^2}$$ -------------------------- (2)

Putting the values of equation 2 we get

$$g = \frac{4\times(3.14)^2\times 1}{(2.01)^2} = \frac{39.4384}{4.0401} = 9.76\,N/kg$$

g = 9.76 N/kg

(21) A student vibrates the end of a spring at 2.6 Hz. This produces a wave with a wavelength of 0.37m. Calculate the speed of the wave.

Solution: Given Data: Frequency = f =2.6 Hz

Wave length = λ = 0.37m

Required: Speed of the wave = v =?

Calculation: we know that v = fλ------------------ 1

v = fλ = 2.6×0.37m/sec

v = 0.962 m/sec

ETEA PAST PAPERS

Oscilation and simple harmonic motion

1. The kinetic energy and potential energy of a particle executing simple harmonic motion will be equal for the displacement (where x_o is the amplitude); 2017-med

A. $x\sqrt{\frac{2}{3}}$ B. x/2
C. $x/\sqrt{2}$ D. $x\sqrt{2}$

C

K.E = P.E
$\rightarrow \frac{1}{2}k(r^2 - x^2) = \frac{1}{2}kx^2$
$\rightarrow (r^2 - x^2) = x^2$
$\rightarrow r^2 = x^2 + x^2$
$\rightarrow r^2 = 2x^2$
$\rightarrow x^2 = r^2/2$
$\rightarrow x = \sqrt{r^2/2}$
$\rightarrow x = r/\sqrt{2}$
$x = a/\sqrt{2}$ where x is displacemt and a is amplitude

2. If x-component of a vector is v3 and y-component is 1, then the angle made by the vector along x-axis is: 2017-med

A. 60° B. 30°
C. 45° D. 90°

A

Tanθ =x-component/y-component.the $\tan\theta = \sqrt{3}/1 \therefore \Theta = \tan^{-1}\sqrt{3} = 60^0$

3. Two springs of spring constants k1 and k2 are stretched by the same force. They are stretched by x1 and x2 respectively. If k1 >k2 then: 2017-eng

a)x1=x2 B)x1>x2
C)x1<x2 D) Depends on the length of the spring

C

4. A spring is stretched by 5 cm. Its potential energy is E. If it is stretched by 10 cm, its potential energy will be 2017-eng

A) 2 B) 4E
C) 8E D)16E

B

5. A particle executes SHM along a straight line. Its amplitude is A The potential energy of the particle is equal to the kinetic energy when the displacement of the particle from the mean POSITION IS ; 2017-med

A.Zero
B. $\pm A/2$
c). $\pm A/\sqrt{2}$
D.2A

C

K.E = P.E
$\rightarrow \frac{1}{2}k(r^2 - x^2) = \frac{1}{2}kx^2$
$\rightarrow (r^2 - x^2) = x^2$
$\rightarrow r^2 = x^2 + x^2$
$\rightarrow r^2 = 2x^2$
$\rightarrow x^2 = r^2/2$
$\rightarrow x = \sqrt{r^2/2}$
$\rightarrow x = r/\sqrt{2}$
$x = a/\sqrt{2}$ where x is displacemt and a is amplitude

6. In S.H.M, the fraction of kinetic energy to total energy when displacement is one-half of the Amplitude is 2017-med

A.1/8 B.1/2

D

$K.E = 1/2k(x^2 - (x/2)^2)$
$= K.E = 1/2k(x^2 - x^2/4$
$= 1/2\ k(3x^2/4) = 3kx^2/8$
$= 3/4\ (kx^2/2) = 3/4$ T.E

C.1/4 D.3/4

7.	The time period of the simple pendulum is 2 second. If its length is increased by 4 times, then its period becomes; 2017-med A. 16s B. 12s C.8s D. 4s	D	$T = 2\pi\sqrt{\frac{l}{g}}$ $T' = 2\pi\sqrt{\frac{4l}{g}}$ $= 2[2\pi\sqrt{\frac{l}{g}}] = 2T = 2 \times 2 = 4$ sec
8.	Two springs of spring constant k2 and K2 are arranged in parallel and a body of mass m is attached to it then calculate the time period of the system: 2018-med A) $2\pi\sqrt{\frac{m}{k1+k2}}$ B) $2\pi\sqrt{\frac{2m}{k1+k2}}$ C) $2\pi\sqrt{\frac{mk1k2}{k1+k2}}$ D) $2\pi\sqrt{\frac{k1+k2}{m}}$	a	Spring arranged in parallel, K_{eq} = k1+k2+k3…..
9.	In SHM the acceleration of the particle is zero when its: 2018-med A) Velocity is zero B) Displacement is zero C) Both velocity and displacement are zero D)Both velocity and displacement are maximum Hints: As a α-x if x=0 than a=0	B	
10.	A mass m is suspended from a spring of spring constant k. The angular frequency of oscillations of the spring is: 2018-med A) k/m B) $\sqrt{\frac{k}{m}}$ C) m/k D) $\sqrt{\frac{m}{k}}$	B	
11.	Which one of the following varies when an object execute simple harmonic motion? 2018-eng A)Angular frequency B)Total energy C)Force D)Amplitude	C	
12.	If a hole is bored through the center of the earth and a pebble is dropped in it, then it will: 2018-eng A)Stop at the center of the earth B) Drop to the other side C)Execute SHM D) Fall with a constant velocity.	C	
13.	A body in simple harmonic motion makes n complete oscillation in one second. The angular frequency of this motion is: 2015- Eng A)πrad-s^{-1} B) $1/\pi$ rad-s^{-1}	C	$f = \frac{Number\ of\ cycle}{Seconds} = \frac{2\pi n rad}{s} = 2\pi$ rad-s^{-1}

C) 2π rad-s^{-1} D) $\frac{\pi}{2\pi} rad - s^{-1}$

14. Circular motion and simple harmonic motion

15. A particle performs simple harmonic motion of amplitude 0.02m and freq 2.5 Hz. what is its maximum speed? Eng-2009-2015

A) 0.0008 ms^{-1} B) 0.125 ms^{-1}

C) 0.157 ms^{-1} D) 0.314 ms^{-1}

Answer: D

Velocity is given by: v $=\omega\sqrt{r^2 - x^2}$, the speed is maximum when x = 2 so v becomes v = $\omega \sqrt{r^2}$ = ωr = (2πf)r =2 x 3.14x2.5 x 0.02 = 0.314 ms^{-1}

NOTE: for maimum velocity x=0 and for zerovelocity r = x

16. If the displacement of a particle executing S.H.M is given by x = $\frac{5}{\pi}$ sin (20πf t) cms, its amplitude is: Eng-2015

2015-115 Eng

A) $\frac{5}{\pi}$m B) $\frac{5}{\pi}$ cm

C) 20πcms D) 100 cms

Answer: B

Given; x = $\frac{5}{\pi}$ sin (20πf t) and we know that; x = x_0 sin (ωt) =x_0 sin (2πft)

Comparing both equations we get; x_0 = $\frac{5}{\pi}$cm where x_0 = amplitude

17. Simple pendulum and Hook's law

18. The total energy of the body executing S.H.M is E. The K.E when the displacement is half of the amplitude is: Eng-2015

A) $\frac{E}{\pi}$ B) $\frac{E}{4}$ C) $\frac{3E}{4}$ D) $\sqrt{\frac{3}{4}E}$

Answer: B

K.E = $\frac{1}{2}$k ($x_o^2 - x^2$)

When x = x_o/2 so = $\frac{1}{2}$k (x_o^2 - $(\frac{x_0}{2})^2$) = $\frac{1}{2}$k (x_o^2 - $\frac{x_0^2}{4}$) = $\frac{1}{2}$k x_o^2 (1- $\frac{1}{4}$) = $\frac{1}{2}$k x_o^2 (3/4)

We know that $\frac{1}{2}$k x_o^2 =E

So K.E= E $\frac{3}{4}$ = $\frac{3E}{4}$

19. At what place, the motion of the bob of simple pendulum will be the slowest? Med-2010

(a) At poles of earth

(b) At equator of earth

(c) Anywhere on the surface of earth

(d) None of these

Answer: B

As earth I oval shape so at equator radius is more, g is low, time period will high ans motion will be slowest.

→ $r \alpha 1/g$

→ $T \alpha 1$/motion

20. A simple pendulum is suspended on the roof of a lift when the lift is moving downward with an acceleration a (a<g), then its time period is given by T= $2\pi\sqrt{\frac{l}{g}}$ where g is equal to ; Eng-2015

A) g B) g-a

C) (g+a D) g^2

Answer: B

When lift is moveing downward, the g decrease by an amount of a, so new g becomes G' = g-a

21. If a tunnel is bored through the centre of the earth and a stone is dropped into it then the: Med- 2010

(a) Stone will stop at the centre of the earth

(b) Stone will move out fro other side of the tunnel

(c) Stone will perform simple harmonic motion

(d) None of these

Answer: C

The stone is attracted by centre of earth and it will reach to ccentre, but due to inertie it doesnot stop at centre but continues its motion but again it is attracted by centre of easth and so on the stone make simple harmonic motion at the centre.

No.	Question	Ans	Explanation
22.	The period of simple pendulum double when: Med-2009 (a) Its length is double (b) The mass of the bob is double (c) Its length is made four time (d) The mass and length of the pendulum is made two times	C	We know that T= $2\pi\sqrt{\frac{l}{g}}$ when lenth is made four times T= $2\pi\sqrt{\frac{4l}{g}}$ = T= $2\pi(2)\sqrt{\frac{l}{g}}$ = (T= $2\pi\sqrt{\frac{l}{g}}$) = 2T
23.	If the length of a simple pendulum is halved and mass is doubled then its time period. Eng-2012 (a) Increases by $\sqrt{2}$ (b) Remains constant (c) Cannot be predicted (d) Decreases by $\sqrt{2}$	A	We know that T= $2\pi\sqrt{\frac{l}{g}}$, so when L=L/2 and m = 2m then T= $2\pi\sqrt{\frac{2l}{g}}$= $\sqrt{2}(2\pi\sqrt{\frac{l}{g}})=\sqrt{2}$T
24.	While determining the expression for time period of simple pendulum, we keep the amplitude, Med-2005 (a) Large (b) Small (c) Maximum (d) Zero	B	The amplitude is kept small because for small θ, sin θ= θ
25.	How much will be the length of a simple pendulum if its time period is one second Med-2010 (a) 2.5 m (b) 0.25 m (c) 25 m (d) 0.025 m	B	We know that T= $2\pi\sqrt{\frac{l}{g}}$, L= $\frac{T^2g}{4\pi^2}$ Putteing t=1 and g=9.8 and T=1 so L= $\frac{T^2g}{4\pi^2}=\frac{1^2 9.8}{4\times(3.14)^2}=\frac{9.8}{4\times9.8}=\frac{1}{4}$= 0.25 m
26.	The displacement 'x' of a particle at time 't' is given by x = 10 sin 4t. the particle oscillates with period. Med-2014 (a) π/10s (b) π/5s (c) π/4s (d) π/2s	D	We know that: x = x_0 sin (ωt) x_0 sin (2πft), given: x = 10 sin 4t. comparing both of these, we get 2πf = 4 → f= 4/2π= 2/π & T=1/f= π/2
27.	If a hole is bored through the center of the earth and a pebble is dropped in it. Then it will: Med-2014 (a) Execute SHM (b) Drop to the other side (c)Stop at the center of the earth (d) None of the above	A	The stone is attracted by centre of earth and it will reach to ccentre, but due to inertie it doesnot stop at centre but continues its motion but again it is attracted by centre of easth and so on the stone make simple harmonic motion at the centre.
28.	The period of a simple pendulum can be increased by: Eng-2014 (a) Decreasing the length of the pendulum. (b) Increasing the length of the pendulum. (c) Increasing the mass of the bob. (d) Decreasing the mass of the bob.	B	T= $2\pi\sqrt{\frac{l}{g}}$, time period is directly proportional to underroot of l , so increasing length will increase the temperatures; NOTE: time period is independent to mas

29. The total energy of a particle executing S.H.M. is: Med- 2016
(a) Inversely proportional to square of amplitude
(b) Directly proportional to the amplitude
(c) Zero
(d) Directly proportional to the square of amplitude

D — We know that $E= \frac{1}{2}k\, x_o^2$ where x_o is amplitude.so energy is directly proportional to the square of amplitude.

30. The time period of a simple pendulum is 2 seconds. If its length is increased by 4 times, then its period becomes: Med-2016
(a) 16 s (b) 12 s
(c) 8 s **(d) 4 s**

D — We know that $T= 2\pi\sqrt{\frac{l}{g}}$, if L=4L then
$T' = 2\pi\sqrt{\frac{4l}{g}} = (2)2\pi\sqrt{\frac{l}{g}} = (2)\,T$
Putting T=2 then T' = 2 x 2 = 4s

31. The kinetic energy and potential energy of a particle executing simple harmonic motion will be equal when displacement is: (Where 'a' is the amplitude) Eng-2016
(a) $a\sqrt{\frac{2}{3}}$ (b) $\frac{a}{2}$
(c) $\frac{a}{\sqrt{2}}$ (d) $a\sqrt{2}$

C — $P.E= \frac{1}{2}k\,x^2$, $K.E = \frac{1}{2}k\,(x_o^2-x^2)$, according to conditions P.E=K.E $\rightarrow \frac{1}{2}k\,x^2 = \frac{1}{2}k\,(x_o^2-x^2) \rightarrow x^2 = x_o^2-x^2 \rightarrow x^2+x^2 = x_o^2 \rightarrow 2x^2 = x_o^2 \rightarrow x^2 = x_o^2/2$ taking underroot
$x = \frac{x_o}{\sqrt{2}} = \frac{a}{\sqrt{2}}$

32. Mass spring system

33. A spring obeying Hook's law has an un stretched length of 50 mm and a spring constant of 400 Nm^{-1}. What is the tension in the spring when its overall length is 70mm? Med-2013
(a) 8.0 N (b) 28 N
(c) 160 N (d) 400 N

A — By Hook's law $F = K\Delta x$,
Here Δx = 70mm-50 mm = 20 mm = 0.02 cm and K = 400 Nm^{-1}. So F = 400 × 0.02 = 8N.
NOTE: tension is simply a force.

34. A spring system executes simple harmonic motion. If a load is added to it then the time period of spring–mass system will be, Med -2012
(a) Increased (b) Decreased
(c) The same (d) Halved

A — Formass spring sytem $T= 2\pi\sqrt{\frac{m}{k}}$.
fre\om equation time period is directly proportional to $\sqrt{m}$ so increase in mass will increase the time period.
NOTE: time period of simple pendulum is independent to mass whilt that of mass spring system directly proportional to $\sqrt{m}$.

35. A weight suspended from an ideal spring oscillates up and down with a period T. If the amplitude of the oscillation is doubled, the period will be: Med-2016
(a) T (b) 1
(c) 2T (d) T

A — We know that; $T= 2\pi\sqrt{\frac{m}{k}}$,the time period of SHM is independent of amplitude of oscillation.

36. Phase

37.	The quantity which specified the displacement as well as the direction of motion in simple harmonic motion is the, Med-2011 (a) Phase angle (b) Angular frequency (c) Path difference (d) None of these	A	The angle θ = ωt wich specifies the displacement x and as wellas the direction of motion of the point oscillating SHM is called phase.

Resonance

38.	The heating and cooking of food evenly by mocro wave oven is an example of: Eng-2010 (a) Resonance (b) Specific heat (c) Damped oscillation (d)None of these	C	Radio, microwave oven and MRI are example of resonance
39.	MRI works on the principle of: Med-2012 (a) Beats (b) Interference (c)Resonance (d)Standing waves	A	Radio, microwave oven and MRI are example of resonance
40.	It is impossible for two particles, each executing simple harmonic motion, to remain in phase with each other if they have different: Eng-2016 (a) Masses (b) Periods (c) Amplitudes (d) Spring constants	C	To remain in phase for two particle, they must have same amplitude.