Chengalpattu District

FIRST REVISION EXAM – JAN 2025

XI - Physics Answer Key

PART - A **I. Answer all the questions. Choose the correct answers. 15x1=15**		
1.	(c)	Increase 4 times
2.	(d)	Angle of contact between the surface and the liquid
3.	(c)	26.8%
4.	(c)	$\frac{27}{17}$
5.	(d)	A straight line
6.	(a)	4.30
7.	(b)	Need not be zero
8.	(c)	0.28%
9.	(b)	25 rad s^{-2}
10.	(c)	10J
11.	(c)	$\frac{m_1}{m_2}\sqrt{\frac{h_1}{h_2}}$
12.	(c)	2.898×10^{-3}mk
13.	(b)	decrease
14.	(d)	$[LT^{-3}]$
15.	(b)	0.2%

II.	PART - B **Answer any six questions. Question No. 24 is compulsory. 6x2=12**
16.	*The centre of mass of a body is defined as a point where the entire mass of the body appears to be concentrated.*
17.	**Dimensional Constant:** Physical quantities which possess dimensions and have constant values are called dimensional constants. Examples are Gravitational constant, Planck's constant etc.
18.	Calculate the energy consumed in electrical units when a 75 W fan is used for 8 hours daily for one month (30 days). ***Solution*** Power, P = 75 W Time of usage, t = 8 hour × 30 days = 240 hours Electrical energy consumed is the product of power and time of usage. Electrical energy = power × time of usage = P × t = 75 watt × 240 hour = 18000 watt hour = 18 kilowatt hour = 18 kWh 1 electrical unit = 1 kWh Electrical energy = 18 unit
19.	Stefan Boltzmann law states that, *the total amount of heat radiated per second per unit area of a black body is directly proportional to the fourth power of its absolute temperature.* $E \propto T^4$ or $E = \sigma T^4$ (8.10) Where, σ is known as Stefan's constant. Its value is 5.67×10^{-8} W $m^{-2} k^{-4}$
20.	Frequency $f = \frac{1}{Time\ period}$, which implies that the dimension of frequency is, $[f] = \frac{1}{[T]} = T^{-1}$ $\Rightarrow [\lambda f] = [\lambda][f] = LT^{-1} = [velocity]$ Therefore, Velocity, $\lambda f = v$ (11.4)
21.	Steel is more elastic than rubber. If an equal stress is applied to both steel and rubber, the steel produces less strain. So the Young's modulus is higher for steel than rubber. The object which has higher Young's modulus is more elastic.
22.	**Distance** is the actual path length travelled by an object in the given interval of time during the motion. It is a positive scalar quantity. **Displacement** is the difference between the final and initial positions of the object in a given interval of time. It can also be defined as the shortest distance between these two positions of the object and its direction is from the initial to final position of the object, during the given interval of time. It is a vector quantity.
23.	*Kinetic theory, the average kinetic energy of system of molecules in thermal equilibrium at temperature T is uniformly distributed to all degrees of freedom (x or y or z directions of motion) so that each degree of freedom will get 12 kT of energy. This is called law of equipartition of energy.*

24. The efficiency of heat engine is given by

$$\eta = 1 - \frac{Q_L}{Q_H}$$

$$\eta = 1 - \frac{300}{500} = 1 - \frac{3}{5}$$

$$\eta = 1 - 0.6 = 0.4$$

The heat engine has 40% efficiency, implying that this heat engine converts only 40% of the input heat into work.

PART - C

III. Answer any six questions. Question No. 33 is compulsory. 6x3=18

25. **This method is used to**
(i) Convert a physical quantity from one system of units to another.
(ii) Check the dimensional correctness of a given physical equation.
(iii) Establish relations among various physical quantities.

26. (a) The velocity $\vec{v} = \frac{d\vec{r}}{dt} = \frac{dx}{dt}\hat{i} + \frac{dy}{dt}\hat{j} + \frac{dz}{dt}\hat{k}$

We obtain, $\vec{v}(t) = 6t\hat{i} + 5\hat{j}$

The velocity has only two components $v_x = 6t$, depending on time t and $v_y = 5$ which is independent of time.

The velocity at t = 3 s is $\vec{v}(3) = 18\hat{i} + 5\hat{j}$

(b) The speed at t = 3 s is $v = \sqrt{18^2 + 5^2} = \sqrt{349} \approx 18.68\, m\, s^{-1}$

27. Geostationary Satellite: It is the satellite which appears at a fixed position and at a definite height to an observer on earth.

Polar Satellite: It is the satellite which revolves in polar orbit around the earth.

28. **Laws of simple pendulum**

The time period of a simple pendulum

a. Depends on the following laws

(i) Law of length

For a given value of acceleration due to gravity, the time period of a simple pendulum is directly proportional to the square root of length of the pendulum.

$$T \propto \sqrt{l} \qquad (10.60)$$

(ii) Law of acceleration

For a fixed length, the time period of a simple pendulum is inversely proportional to square root of acceleration due to gravity.

$$T \propto \frac{1}{\sqrt{g}} \qquad (10.61)$$

29. **Linear Expansion**

In solids, for a small change in temperature ΔT, the fractional change in length $\left(\frac{\Delta L}{L_0}\right)$ is directly proportional to ΔT.

$$\frac{\Delta L}{L_0} = \alpha_L \Delta T$$

Therefore, $\alpha_L = \frac{\Delta L}{L_0 \Delta T}$

Where, α_L = coefficient of linear expansion.

ΔL = Change in length

L_0 = Original length

ΔT = Change in temperature.

Area Expansion

For a small change in temperature ΔT the fractional change in area $\left(\frac{\Delta A}{A_0}\right)$ of a substance is directly proportional to ΔT and it can be written as

$$\frac{\Delta A}{A_0} = \alpha_A \Delta T$$

Therefore, $\alpha_A = \frac{\Delta A}{A_0 \Delta T}$

Where, α_A = coefficient of area expansion.

ΔA = Change in area

A_0 = Original area

ΔT = Change in temperature

Volume Expansion

For a small change in temperature ΔT the fractional change in volume $\left(\frac{\Delta V}{V_0}\right)$ of a substance is directly proportional to ΔT.

$$\frac{\Delta V}{V_0} = \alpha_V \Delta T$$

Therefore, $$\alpha_V = \frac{\Delta V}{V_0 \Delta T}$$

Where, α_V = coefficient of volume expansion.

ΔV = Change in volume

V_0 = Original volume

ΔT = Change in temperature

Unit of coefficient of linear, area and volumetric expansion of solids is $^{\circ}C^{-1}$ or K^{-1}

30.

Progressive waves	Stationary waves
Crests and troughs are formed in transverse progressive waves, and compression and rarefaction are formed in longitudinal progressive waves. These waves move forward or backward in a medium i.e., they will advance in a medium with a definite velocity.	Crests and troughs are formed in transverse stationary waves, and compression and rarefaction are formed in longitudinal stationary waves. These waves neither move forward nor backward in a medium i.e., they will not advance in a medium.
All the particles in the medium vibrate such that the amplitude of the vibration for all particles is same.	Except at nodes, all other particles of the medium vibrate such that amplitude of vibration is different for different particles. The amplitude is minimum or zero at nodes and maximum at anti-nodes.
These wave carry energy while propagating.	These waves do not transport energy.

31. Every object continues to be in the state of rest or of uniform motion (constant velocity) unless there is external force acting on it.

The force acting on an object is equal to the rate of change of its momentum.

Newton's third law states that for every action there is an equal and opposite reaction.

32.

Elastic Collision	Inelastic Collision
Total momentum is conserved	Total momentum is conserved
Total kinetic energy is conserved	Total kinetic energy is not conserved
Forces involved are conservative forces	Forces involved are non-conservative forces
Mechanical energy is not dissipated.	Mechanical energy is dissipated into heat, light, sound etc.

33. For a flute which is an open pipe, we have

Second harmonics $f2 = 2\,f1 = 900$ Hz

Third harmonics $f3 = 3\,f1 = 1350$ Hz

Fourth harmonics $f4 = 4\,f1 = 1800$ Hz

PART - D

IV. **Answer in detail.** **5x5=25**

34. (a) Meyer's relation:

Consider μ mole of an ideal gas in a container with volume V, pressure P and temperature T.

When the gas is heated at constant volume the temperature increases by dT. As no work is done by the gas, the heat that flows into the system will increase only the internal energy. Let the change in internal energy be dU.

If C_v is the molar specific heat capacity at constant volume, from equation (8.20)

$$dU = \mu C_v dT \quad (8.21)$$

$$Q = \mu C_p dT \quad (8.22)$$

If W is the workdone by the gas in this process, then

$$W = PdV \quad (8.23)$$

But from the first law of thermodynamics,

$$Q = dU + W \quad (8.24)$$

Substituting equations (8.21), (8.22) and (8.23) in (8.24), we get,

$$\mu C_p dT = \mu C_v dT + PdV \quad (8.25)$$

For mole of ideal gas, the equation of state is given by

$$PV = \mu RT \Rightarrow PdV + VdP = \mu RdT \quad (8.26)$$

Since the pressure is constant, dP=0

$$\therefore C_p dT = C_v dT + RdT$$

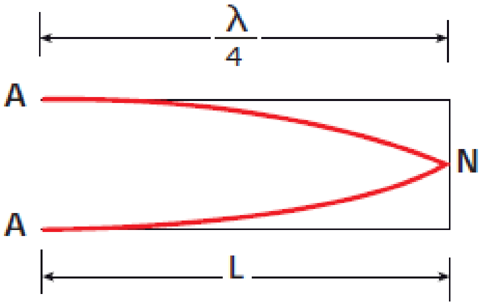
$$\therefore C_p = C_v + R \quad \text{(or)} \quad C_p - C_v = R \quad (8.27)$$

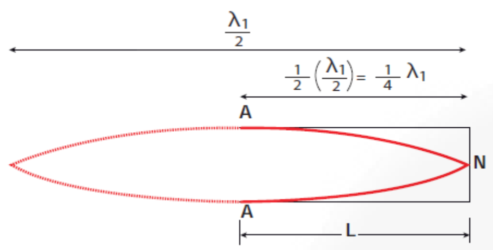
This relation is called Meyer's relation

34. (b) Closed organ pipes:

Look at the picture of a clarinet, shown in Figure 11.36. It is a pipe with one end closed and the other end open. If one end of a pipe is closed, the wave reflected at this closed end is 180° out of phase with the incoming wave. Thus there is no displacement of the particles at the closed end. Therefore, nodes are formed at the closed end and anti-nodes are formed at open end.

Let us consider the simplest mode of vibration of the air column called the fundamental mode. Anti-node is formed at the open end and node at closed end.





let L be the length of the tube and the wavelength of the wave produced. For the fundamental mode of vibration, we have

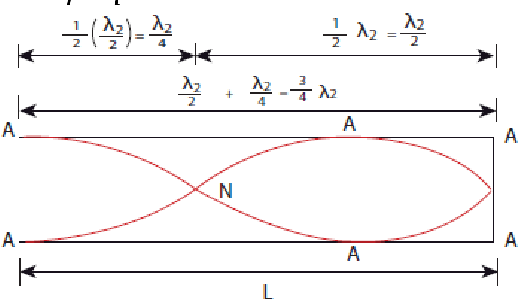
$$L = \frac{\lambda_1}{4} \; or \; \lambda_1 = 4L \qquad (11.74)$$

The frequency of the note emitted is

$$f_1 = \frac{v}{\lambda_1} = \frac{v}{4L} \qquad (11.75)$$

which is called the fundamental note.

The frequencies higher than fundamental frequency can be produced by blowing air strongly at open end. Such frequencies are called overtones.



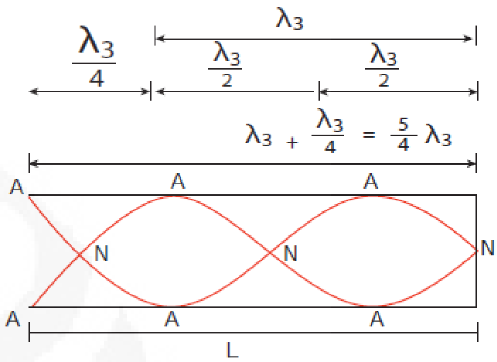
$$4L = 3\lambda_2$$

$$L = \frac{3\lambda_2}{4} \text{ or } \lambda_2 = \frac{4L}{3}$$

The frequency for this,

$$f_2 = \frac{v}{\lambda_2} = \frac{3v}{4L} = 3f_1$$

is called *first over tone*, since here, the frequency is three times the fundamental frequency it is called *third harmonic*.



We have, $4L = 5\lambda_3$

$$L = \frac{5\lambda_3}{4} \text{ or } \lambda_3 = \frac{4L}{5}$$

The frequency

$$f_3 = \frac{v}{\lambda_3} = \frac{5v}{4L} = 5f_1$$

is called *second over tone*, and since $n = 5$ here, this is called *fifth harmonic*. Hence, *the closed organ pipe has only odd harmonics and frequency of the* n^{th} *harmonic is* $f_n = (2n+1)f_1$. Therefore, *the frequencies of harmonics are in the ratio*

$$f_1 : f_2 : f_3 : f_4 : \ldots = 1 : 3 : 5 : 7 : \ldots \qquad (11.76)$$

35. (a) **Errors in Measurement**

The uncertainty in a measurement is called an error. Random error, systematic error and gross error are the three possible errors.

i) Systematic errors: Systematic errors are reproducible inaccuracies that are consistently in the same direction. These occur often due to a problem that persists throughout the experiment. Systematic errors can be classified as follows

1) Instrumental errors : When an instrument is not calibrated properly at the time of manufacture, instrumental errors may arise. If a measurement is made with a meter scale whose end is worn out, the result obtained will have errors. These errors can be corrected by choosing the instrument carefully.

2) Imperfections in experimental technique or procedure: These errors arise due to the limitations in the experimental arrangement. As an example, while **performing** experiments with a calorimeter, if there is no proper insulation, there will be radiation losses. This results in errors and to overcome these, necessary correction has to be applied.

3) Personal errors: These errors are due to individuals performing the experiment, may be due to incorrect initial setting up of the experiment or carelessness of the individual making the observation due to improper precautions.

4) Errors due to external causes: The change in the external conditions during an experiment can cause error in measurement. For example, changes in temperature, humidity, or pressure during measurements may affect the result of the measurement.

5) Least count error: Least count is the smallest value that can be measured by the measuring instrument, and the error due to this measurement is least count error. The instrument's resolution hence is the cause of this error. Least count error can be reduced by using a high precision instrument for the measurement.

ii) Random errors: Random errors may arise due to random and unpredictable variations in experimental conditions like pressure, temperature, voltage supply etc. Errors may also be due to personal errors by the observer who performs the experiment. Random errors are sometimes called "chance error". When different readings are obtained by a person every time he repeats the experiment, personal error occurs. For example, consider the case of the thickness of a wire measured using a screw gauge. The readings taken may be different for different trials. In this case, a large number of measurements are made and then the arithmetic mean is taken.

If n number of trial readings are taken in an experiment, and the readings are a1, a2, a3,..................... an. The arithmetic mean is

$$a_m = \frac{a_1 + a_2 + a_3 + ...a_n}{n} \quad (1.1)$$

or

$$a_m = \frac{1}{n}\sum_{i=1}^{n} a_i \quad (1.2)$$

Usually this arithmetic mean is taken as the best possible true value of the quantity.

Certain procedures to be followed to minimize experimental errors.

iii) Gross Error: The error caused due to the shear carelessness of an observer is called gross error.

For example

(i) Reading an instrument without setting it properly.

(ii) Taking observations in a wrong manner without bothering about the sources of errors and the precautions.

(iii) Recording wrong observations.

(iv) Using wrong values of the observations in calculations.

These errors can be minimized only when an observer is careful and mentally alert.

35. (b)

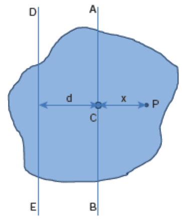
Parallel axis theorem:

Parallel axis theorem states that the moment of inertia of a body about any axis is equal to the sum of its moment of inertia about a parallel axis through its centre of mass and the product of the mass of the body and the square of the perpendicular distance between the two axes.

If I_C is the moment of inertia of the body of mass M about an axis passing through the centre of mass, then the moment of inertia I about a parallel axis at a distance d from it is given by the relation,

$$I = I_C + Md^2 \quad (5.46)$$

Let us consider a rigid body as shown in Figure 5.25. Its moment of inertia about an axis AB passing through the centre of mass is I_C. DE is another axis parallel to AB at a perpendicular distance d from AB. The moment of inertia of the body about DE is I. We attempt to get an expression for I in terms of I_C. For this, let us consider a point mass m on the body at position x from its centre of mass.



The moment of inertia of the point mass about the axis DE is, $m(x+d)^2$.

The moment of inertia I of the whole body about DE is the summation of the above expression.

$$I=\sum m(x+d)^2$$

This equation could further be written as,

$$I=\sum m(x^2+d^2+2xd)$$
$$I=\sum (mx^2+md^2+2dmx)$$
$$I=\sum mx^2+\sum md^2+2d\sum mx$$

Here, $\sum mx^2$ is the moment of inertia of the body about the centre of mass. Hence, $I_C=\sum mx^2$

The term, $\sum mx=0$ because, x can take positive and negative values with respect to the axis AB. The summation $(\sum mx)$ will be zero.

Thus, $I=I_C+\sum md^2=I_C+(\sum m)d^2$

Here, $\sum m$ is the entire mass M of the object $(\sum m=M)$

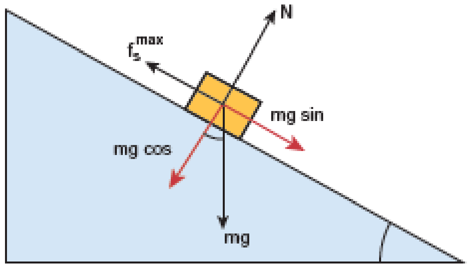
$$I=I_C+Md^2$$

Hence, the parallel axis theorem is proved.

36. (a)

Angle of Repose:

Consider an inclined plane on which an object is placed, as shown in Figure 3.29. Let the angle which this plane makes with the horizontal be θ . For small angles of θ , the object may not slide down. As θ is increased, for a particular value of θ , the object begins to slide down. This value is called angle of repose. Hence, the angle of repose is the angle of inclined plane with the horizontal such that an object placed on it begins to slide.



Let us consider the various forces in action here. The gravitational force mg is resolved into components parallel (*mg* sinθ) and perpendicular (*mg* cosθ) to the inclined plane.

The component of force parallel to the inclined plane (mg sinθ) tries to move the object down.

The component of force perpendicular to the inclined plane (mg cosθ) is balanced by the Normal force (N).

$$N=mg\cos\theta$$

When the object just begins to move, the static friction attains its maximum value

$$f_s=f_s^{max}=\mu_sN=\mu_s mg\cos\theta \quad (3.35)$$

This friction also satisfies the relation

$$f_s^{max}=mg\sin\theta \quad (3.36)$$

Dividing equations (3.35) and (3.36), we get

$$\mu_s=\sin\theta/\cos\theta$$

From the definition of angle of friction, we also know that

$$\tan\theta=\mu_s, \quad (3.37)$$

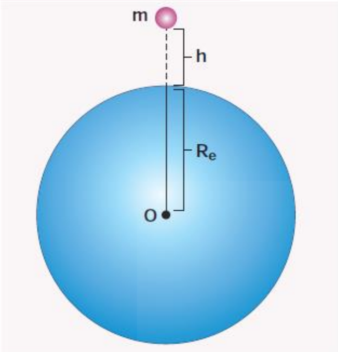
in which θ is the angle of friction.

Thus the angle of repose is the same as angle of friction. But the difference is that the angle of repose refers to inclined surfaces and the angle of friction is applicable to any type of surface.

36. (b) **Variation of g with altitude, depth and latitude**

Consider an object of mass m at a height h from the surface of the Earth. Acceleration experienced by the object due to Earth is

$$g' = \frac{GM}{(R_e + h)^2}$$



$$g' = \frac{GM}{R_e^2\left(1+\frac{h}{R_e}\right)^2}$$

$$g' = \frac{GM}{R_e^2}\left(1+\frac{h}{R_e}\right)^{-2}$$

If $h \ll R_e$

We can use Binomial expansion. Taking the terms upto first order

$$g' = \frac{GM}{R_e^2}\left(1-2\frac{h}{R_e}\right)$$

$$g' = g\left(1-2\frac{h}{R_e}\right) \qquad (6.46)$$

We find that $g' < g$. This means that as altitude h increases the acceleration due to gravity g decreases.

37. (a) There are three types of elastic modulus.

(a) Young's modulus

(b) Rigidity modulus (or Shear modulus)

(c) Bulk modulus

Young's modulus:

When a wire is stretched or compressed, then the ratio between tensile stress (or compressive stress) and tensile strain (or compressive strain) is defined as Young's modulus.

Young modulus of a material

$$= \frac{\text{Tensile stress or compressive stress}}{\text{Tensile strain or compressive strain}}$$

$$Y = \frac{\sigma_t}{\varepsilon_t} \quad \text{or} \quad Y = \frac{\sigma_c}{\varepsilon_c} \qquad (7.6)$$

Bulk modulus:

The bulk modulus is defined as the ratio of the volume stress to the volume strain.

Bulk modulus, K =

$$\frac{\text{Normal (Perpendicular) stress or Pressure}}{\text{Volume strain}}$$

The normal stress or pressure is

$$\sigma_n = \frac{F_n}{\Delta A} = \Delta p$$

The volume strain is

$$\varepsilon_v = \frac{\Delta V}{V}$$

Therefore, Bulk modulus is

$$K = -\frac{\sigma_n}{\varepsilon_v} = -\frac{\Delta P}{\frac{\Delta V}{V}} \qquad (7.7)$$

Rigidity modulus or shear modulus:

The rigidity modulus is defined as the ratio of the shearing stress to the shearing strain.

$$\eta_R = \frac{\text{Shearing stress}}{\text{Angle of shear or shearing strain}}$$

The shearing stress is

$$\sigma_s = \frac{\text{Tangential force}}{\text{Area over which it is applied}} = \frac{F_t}{\Delta A}$$

The angle of shear or shearing strain

$$\varepsilon_s = \frac{x}{h} = \theta$$

Therefore, Rigidity modulus is

$$\eta_R = \frac{\sigma_s}{\varepsilon_s} = \frac{\frac{F_t}{\Delta A}}{\frac{x}{h}} = \frac{F_t}{\Delta A \theta} \qquad (7.9)$$

37. (b)

Let F be the applied force towards right as shown in Figure 10.18. Since the spring constants for different spring are different and the connection points between them is not rigidly fixed, the strings can stretch in different lengths. Let x_1 and x_2 be the elongation of springs from their equilibrium position (un-stretched position) due to the applied force F. Then, the net displacement of the mass point is

$$x = x_1 + x_2 \qquad (10.37)$$

From Hooke's law, the net force

$$F = -k_s(x_1 + x_2) \Rightarrow x_1 + x_2 = -\frac{F}{k_s} \qquad (10.38)$$

For springs in series connection

$$-k_1x_1 = -k_2x_2 = F$$

$$\Rightarrow x_1 = -\frac{F}{k_1} \text{ and } x_2 = -\frac{F}{k_2} \qquad (10.39)$$

Therefore, substituting equation (10.39) in equation (10.38), the *effective spring constant* can be calculated as

$$-\frac{F}{k_1} - \frac{F}{k_2} = -\frac{F}{k_s}$$

$$\frac{1}{k_s} = \frac{1}{k_1} + \frac{1}{k_2}$$

Or

$$k_s = \frac{k_1k_2}{k_1 + k_2}\ \text{Nm}^{-1} \qquad (10.40)$$

Suppose we have "n" springs connected in series, the effective spring constant in series is

$$\frac{1}{k_s} = \frac{1}{k_1} + \frac{1}{k_2} + \frac{1}{k_3} + \ldots + \frac{1}{k_n} = \sum_{i=1}^{n}\frac{1}{k_i} \qquad (10.41)$$

If all spring constants are identical i.e., $k_1 = k_2 = \ldots = k_n = k$ then

$$\frac{1}{k_s} = \frac{n}{k} \Rightarrow k_s = \frac{k}{n} \qquad (10.42)$$

This means that the effective spring constant reduces by the factor "n". Hence, for springs in series connection, the effective spring constant is lesser than the individual spring constants.

From equation (10.39), we have,

$$k_1x_1 = k_2x_2$$

Then the ratio of compressed distance or elongated distance x_1 and x_2 is

$$\frac{x_2}{x_1} = \frac{k_1}{k_2} \qquad (10.43)$$

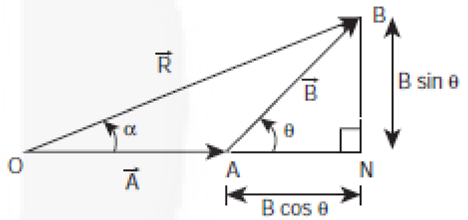
The elastic potential energy stored in first and second springs are $U_1 = \frac{1}{2}k_1x_1^2$ and $U_2 = \frac{1}{2}k_2x_2^2$ respectively. Then, their ratio is

$$\frac{U_1}{U_2} = \frac{\frac{1}{2}k_1x_1^2}{\frac{1}{2}k_2x_2^2} = \frac{k_1}{k_2}\left(\frac{x_1}{x_2}\right)^2 = \frac{k_2}{k_1} \qquad (10.44)$$

38. (a)

We apply the triangular law of addition as follows:

Represent the vectors $\vec{A}$ $\vec{B}$ and by the two adjacent sides of a triangle taken in the same order. Then the resultant is given by the third side of the triangle taken in the reverse order



(1) Magnitude of resultant vector

The magnitude and angle of the resultant vector are determined as follows.

From Figure 2.18, consider the triangle ABN, which is obtained by extending the side OA to ON. ABN is a right angled triangle.

$$\cos\theta = \frac{AN}{B} \quad \therefore AN = B\cos\theta \text{ and}$$

$$\sin\theta = \frac{BN}{B} \quad \therefore BN = B\sin\theta$$

For ΔOBN, we have $OB^2 = ON^2 + BN^2$

$$\Rightarrow R^2 = (A + B\cos\theta)^2 + (B\sin\theta)^2$$

$$\Rightarrow R^2 = A^2 + B^2\cos^2\theta + 2AB\cos\theta + B^2\sin^2\theta$$

$$\Rightarrow R^2 = A^2 + B^2(\cos^2\theta + \sin^2\theta) + 2AB\cos\theta$$

$$\Rightarrow R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

(2) **Direction of resultant vectors:** If θ is the angle between $\vec{A}$ and $\vec{B}$, then

$$\left|\vec{A}+\vec{B}\right| = \sqrt{A^2 + B^2 + 2AB\cos\theta} \quad (2.1)$$

If $\vec{R}$ makes an angle α with $\vec{A}$, then in ΔOBN,

$$\tan\alpha = \frac{BN}{ON} = \frac{BN}{OA + AN}$$

$$\tan\alpha = \frac{B\sin\theta}{A + B\cos\theta}$$

$$\Rightarrow \alpha = \tan^{-1}\left(\frac{B\sin\theta}{A + B\cos\theta}\right)$$

38. (b)

Relation between power and velocity

The work done by a force $\vec{F}$ for a displacement $d\vec{r}$ is

$$W = \int \vec{F}\cdot d\vec{r} \quad (4.40)$$

Left hand side of the equation (4.40) can be written as

$$W = \int dW = \int \frac{dW}{dt}dt$$

(multiplied and divided by dt) (4.41)

Since, velocity is $\vec{v} = \frac{d\vec{r}}{dt}$; $d\vec{r} = \vec{v}\,dt$. Right hand side of the equation (4.40) can be written as

$$\int \vec{F}\cdot d\vec{r} = \int\left(\vec{F}\cdot\frac{d\vec{r}}{dt}\right)dt = \int\left(\vec{F}\cdot\vec{v}\right)dt \quad \left[\vec{v} = \frac{d\vec{r}}{dt}\right] \quad (4.42)$$

Substituting equation (4.41) and equation (4.42) in equation (4.40), we get

$$\int \frac{dW}{dt}dt = \int\left(\vec{F}\cdot\vec{v}\right)dt$$

$$\int\left(\frac{dW}{dt} - \vec{F}\cdot\vec{v}\right)dt = 0$$

This relation is true for any arbitrary value of dt. This implies that the term within the bracket must be equal to zero, i.e.,

$$\frac{dW}{dt} - \vec{F}\cdot\vec{v} = 0$$

Or

$$\frac{dW}{dt} = \vec{F}\cdot\vec{v} = P \quad (4.43)$$