MINISTRY OF SCIENCE AND TECHNOLOGY

DEPARIMENT OF

TECHNICAL AND VOCATIONAL EDUCATION

Sample Questions & Worked Out Examples For

Esc – 01011 ENGINEERING SCIENCE Part (II) { EPh – 01011 Engineering Physics }

A.G.T.I (First Year)

All Courses

SOLUTIONS

FOR

E.Ph 01011

ENGINEERING PHYSICS

- * Must Know
- ** Should Know
- *** Could Know

NOTE: Respective examples in each chapter must be taken as MUST KNOW.

CHAPTER I

Question :

*
1.1 What do you understand by the term " dimension of a physicc quantity ?

Solution:

Dimension of a physical quantity is the power which is needed to put on base quantities.

*
1.2 Write down the dimensional notations for the following quantities :

(a) momentum (b) the constant of gravitation G

(c) potential energy (d) torque or moment of force .

Solution:

(a) momentum = mass x velocity

$$= \text{mass} \times \frac{\text{length}}{\text{time}} = [MLT^{-1}]$$

(b) force $= G \dfrac{\text{mass} \times \text{mass}}{(\text{distance})^2}$ (Universal gravitational law)

$$\therefore \quad G = \frac{\text{force} \times (\text{distance})^2}{(\text{mass})^2}$$

Since force $= \text{mass} \times \dfrac{\text{length}}{(\text{time})^2}$

$$G = \frac{\text{mass} \times \text{length}}{(\text{time})^2} \times \frac{(\text{distance})^2}{(\text{mass})^2}$$

$$= [M^{-1}L^3T^{-2}]$$

(c) potential energy = mass x acceleration due to gravity x height

$$= [MLT^{-2}L]$$

$$= [ML^2T^{-2}]$$

(d) torque or moment of force = force × perpendicular distance

$$= [MLT^{-2}][L]$$

$$= [ML^2T^{-2}]$$

*
1.3 State the principle of dimensional homogeneity.

Solution :

A physically correct equation must have the same dimensions (or units) on both the right-hand side (RHS) and the left-hand side (LHS) of the equation.

*
1.4 What are the fundamental quantities? How many are there, and what are they?

Solution :

Fundamental quantities are quantities which are used to describe other physical quantities.

There are seven fundamental quantities and they are :

(i) Length

(ii) Mass

(iii) Time

(iv) Electric current

(v) Temperature

(vi) Amount of substance

(vii) Luminous intensity

*
1.5 What are derived quantities?

Solution:

Derived quantities are physical quantities, which can be described in terms of fundamental quantities.

*
1.6 In the statement "The mass of a block wood is 2 kilogram", what does kilogram stand for and what does kilogram stand for and what does 2 stand for.

Solution :

Kilogram stand for unit and 2 stand for numerical magnitude.

*1.7. Is mass a fundamental physical quantity (or) derived quantity? Give reason.

Solution:

Yes, mass is a fundamental physical quantity. Other physica quantities such as momentum, force and kinetic energy can be described in terms of mass as shown below.

$$\text{momentum} = \text{mass} \times \text{velocity}$$

$$\text{force} = \text{mass} \times \text{acceleration}$$

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times (\text{velocity})^2$$

*1.8 Is force a fundamental quantity? Give reason.

Solution:

No, force is not a fundamental quantity. It is a derived quantity. Force can be described by fundamental quantities, mass, length and time as shown below.

$$\text{force} = \text{mass} \times \text{acceleration}$$

$$= \text{mass} \times \frac{\text{length}}{(\text{time})^2}$$

CHAPTER I

Problems

*1.1 Change 1 lb force into newtons.

Solution :

Dimension of force $= [MLT^{-2}]$

Moreover, $\left[\frac{M_1}{M_2}\right] = \frac{1\text{ slug}}{1\text{ kg}} = \frac{14.59\text{ kg}}{1\text{ kg}} = 14.59$

$\left[\frac{L_1}{L_2}\right] = \frac{1\text{ ft}}{1\text{ m}} = \frac{0.3048\text{ m}}{1\text{ m}} = 0.3048$

and $\left[\frac{T_1}{T_2}\right] = \frac{1\text{s}}{1\text{s}} = 1$

In this case, $n_1 = 1$ (1 lb force)

$$n_2 = n_1\left[\frac{M_1}{M_2}\right]\left[\frac{L_1}{L_2}\right]\left[\frac{T_1}{T_2}\right]^{-2}$$

$$= 1\,[14.59][0.3048][1]^{-2}$$

$$= 4.447$$

Thus, 1 lb $= 4.447$ N

*1.2 Express the standard atmospheric pressure of 1.013×10^{6} dynes cm^{-2} into SI and FPS unit.

Solution:

Since pressure is the normal force per unit area, the dimension of pressure can be expressed as follows:

$$\text{Dimension of pressure} = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$$

case I : dynes cm^{-2} to Nm^{-2}:

$\left[\frac{M_1}{M_2}\right] = \frac{1\text{g}}{1\text{ kg}} = \frac{10^{-3}\text{ kg}}{1\text{ kg}} = 10^{-3}$

$\left[\frac{L_1}{L_2}\right] = \frac{1\text{cm}}{1\text{m}} = \frac{10^{-2}\text{m}}{1\text{m}} = 10^{-2}$

$\left[\frac{T_1}{T_2}\right] = \frac{1\text{s}}{1\text{s}} = 1$

1.2 In this case, $n_1 = 1.013 \times 10^6$

$$n_2 = n_1 \left[\frac{M_1}{M_2}\right]\left[\frac{L_1}{L_2}\right]^{-1}\left[\frac{T_1}{T_2}\right]^{-2}$$

$$= 1.013 \times 10^6 \left[10^{-3}\right]\left[10^{-2}\right]^{-1}\left[1\right]^{-2}$$

$$= 1.013 \times 10^6 \left[10^{-3}\right]\left[10^{2}\right]$$

$$= 1.013 \times 10^5$$

$\therefore$ 1.013×10^6 dynes cm^{-2} $= 1.013 \times 10^5$ Nm^2

$= 1.013 \times 10^5$ Pa

Case II : dynes cm^{-2} to $lb\,ft^{-2}$:

$$\left[\frac{M_1}{M_2}\right] = \frac{1g}{1\,slug} = \frac{6.85 \times 10^{-5}\,slug}{1\,slug} = 6.85 \times 10^{-5}$$

$$\left[\frac{L_1}{L_2}\right] = \frac{1cm}{1\,ft} = \frac{3.281 \times 10^{-2}\,ft}{1\,ft} = 3.281 \times 10^{-2}$$

$$\left[\frac{T_1}{T_2}\right] = \frac{1s}{1s} = 1$$

In this case, $n_1 = 1.013 \times 10^6$

$$n_2 = n_1 \left[\frac{M_1}{M_2}\right]\left[\frac{L_1}{L_2}\right]^{-1}\left[\frac{T_1}{T_2}\right]^{-2}$$

$$= 1.013 \times 10^6 \left[6.85 \times 10^{-5}\right]\left[3.281 \times 10^{-2}\right]^{-1}\left[1\right]^{-2}$$

$$= 1.013 \times 10^6 \left[6.85 \times 10^{-5}\right]\left[\frac{10^2}{3.281}\right]$$

$$= 2.115 \times 10^3$$

$\therefore$ 1.013×10^6 dynes cm^{-2} $= 2.115 \times 10^3$ $lb\,ft^{-2}$.

* 1.3 Test by the method of dimensions, the correctness of the following equations:

$$v = v_0 + at$$

$$s = v_0 t + \frac{1}{2} at^2$$

where,
s = distance travelled
v_0 = initial velocity
v = final velocity
a = acceleration and
t = time

Solution :

$$v = v_0 + at$$

L.H.S : Dimension of $v = [LT^{-1}]$

R.H.S : Dimension of $(v_0 + at) = [LT^{-1}] + [LT^{-2}][T]$

$= [LT^{-1}] + [LT^{-1}]$

$= [LT^{-1}]$

The equation $v = v_0 + at$ is dimensionally correct.

$$s = v_0 t + \frac{1}{2} at^2$$

L.H.S : Dimensions of $S = [L]$

R.H.S : Dimensions of $(v_0 t + \frac{1}{2} at^2) = [LT^{-1}][T] + [LT^{-2}][T^2]$

$= [L] + [L]$

$= [L]$

The equation $s = v_0 t + \frac{1}{2} at^2$ is dimensionally correct.

CHAPTER TWO
QUESTIONS

*Q.2.1. Can two vectors of different magnitude be combined to give a zero resultant? Can three vectors?

No, it cannot

Let the two vectors are $\vec{A}$ and $\vec{B}$.

To get $\vec{A} + \vec{B} = 0$

$$\vec{A} = -\vec{B}$$

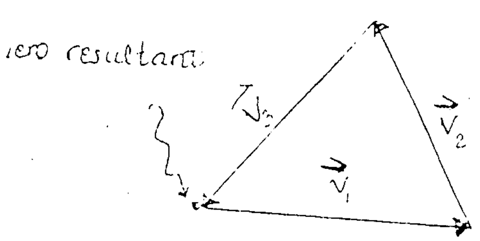
That means to get zero resultant, the two vectors must have same magnitude with opposite direction. So the two vectors having different magnitudes cannot give zero resultant.

Yes, it can.

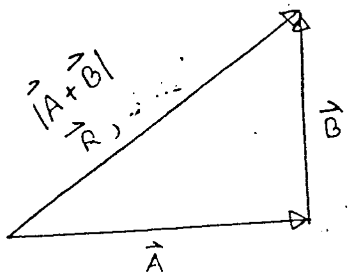
If the resultant of any two vectors has same magnitude with opposite direction to the remaining vector (the third ve their resultant will be zero.

(OR)

If the three vectors can form a (close) triangle their resultant will be zero as in figure



Q. 2.9. Two vectors $\vec{A}$ and $\vec{B}$ are added. Can the magnitude of the resultant of $\vec{A}$ and $\vec{B}$ be greater than A + B ?



No.

If the two vectors $\vec{A}$ and $\vec{B}$ are added by using triangular method, two sides of the triangle stand for magnitudes of the two vectors and the remaining side represents for the resultand vector. But any side of triangle cannot be longer than the sum of the rest two vectors.

$|\vec{A}+\vec{B}|$, therefore, can never be greater than A + B

Q. 2.8. Two vectors $\vec{A}$ and $\vec{B}$ are added. Can the magnitude of the resultant of $\vec{A}$ and $\vec{B}$ be less than A − B ?

No,

Let $\vec{A}+\vec{B}=\vec{R}$ and θ is angle between $\vec{A}$ and $\vec{B}$

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

R will be minimum if $\theta = 180^\circ$, i.e $R_{min} = A - B$. That indicate R_{min} can never be less than A − B. Therefore $|\vec{A}+\vec{B}|$ cannot be less than A − B.

**

Q.2.12. What are the properties of two vectors $\vec{A}$ and $\vec{B}$ such that

(a) $\vec{A} + \vec{B} = \vec{C}$ and $A + B = C$ (b) $|\vec{A} + \vec{B}| = |\vec{A} - \vec{B}|$

(c) $\vec{A} + \vec{B} = \vec{C}$ and $A^2 + B^2 = C^2$

(a) $\vec{C} = \vec{A} + \vec{B}$

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

if $\theta = 0$

$$C = \sqrt{A^2 + B^2 + 2AB} = \sqrt{(A+B)^2} \quad , \quad C = A + B$$

to satisfy the condition $\vec{A} + \vec{B} = \vec{C}$ and $A + B = C$, the angle between $\vec{A}$ and $\vec{B}$ must be zero (OR) $\vec{A}$ and $\vec{B}$ must have same direction.

(OR)

$$\vec{C} = \vec{A} + \vec{B} \quad , \quad C = A + B$$

$$C^2 = A^2 + B^2 + 2AB\cos\theta$$

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

$$A^2 + B^2 + 2AB = A^2 + B^2 + 2AB\cos\theta$$

$$\cos\theta = 1$$

$$\theta = 0, 2\pi, 4\pi, ---$$

$$\theta = 0$$

Q.2.12

(b) $|\vec{A}+\vec{B}| = |\vec{A}-\vec{B}|$

Let 'θ' be angle between $\vec{A}$ and $\vec{B}$

$|\vec{A}+\vec{B}|^2 = A^2 + B^2 + 2AB\cos\theta$ and

$|\vec{A}-\vec{B}|^2 = A^2 + B^2 - 2AB\cos\theta$

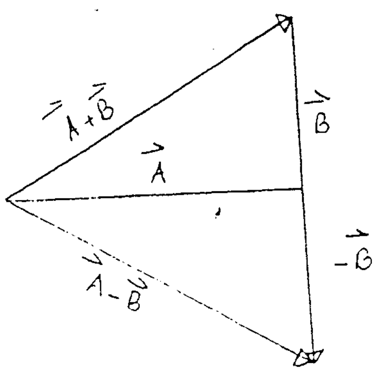
since $|\vec{A}+\vec{B}| = |\vec{A}-\vec{B}|$

$4AB\cos\theta = 0$

$\cos\theta = 0$

$\theta = \pi/2, 3\pi/2, \ldots$

$\vec{A} \perp \vec{B}$



(c) $\vec{C} = \vec{A} + \vec{B}$, $C^2 = A^2 + B^2$

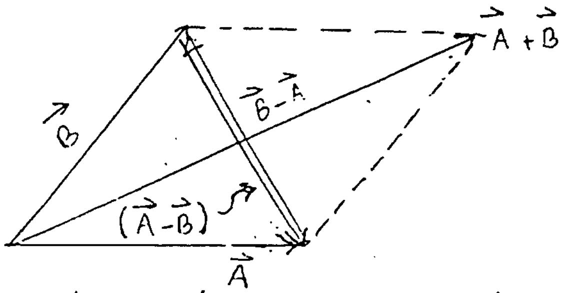
$C^2 = A^2 + B^2 + 2AB\cos\theta = A^2 + B^2$

$\cos\theta = 0$, $\theta = \pi/2, 3\pi/2, \ldots$

$\therefore \vec{A} \perp \vec{B}$

To satisfy the conditions $\vec{A}+\vec{B} = \vec{C}$ and $A^2 + B^2 = C^2$, $\vec{A}$ and $\vec{B}$ must be perpendicular to each other.

** Q.2.13. When two vectors are represented by adjacent side of parallelogram, the diagonal drawn through the corner, from which the vector starts, represent the sum of two given vectors. What does the other diagonal of the same parallelogram represent?



The other diagonal can represent the difference of the given vectors. Let the two given vectors are $\vec{A}$ and $\vec{B}$. If the diagonal that passes the stariting points of $\vec{A}$ and $\vec{B}$ gives the same $(\vec{A}+\vec{B})$. the other diagonal will give the difference $\vec{A}-\vec{B}$ or $\vec{B}-\vec{A}$.

* Q.2.14. Can the displacement of a particle in any time interval have a magnitude which is less than the distance travelled by the particle along its path in that interval? Can its magnitude be more than the distance travelled? Explain.

Yes, the magnitude of the displacement of a particle in any time interval can be less than the distance convered in that time interval.

No, the magnitude of displacement never be greater than the distance convered.

It is already defined as the distance is length measured along the path and the displacement is the directed straight line segment from initial point to final point. The straight line distance is the shortest one between any two points. (i.e the straight path is ever shorter than any other paths those join between two points.) So the magnitude of displacement is ever less than the distance covered during a particular time interval.

**
Q.2.15. Give an example in which the distance travelled is a significant amount yet the corresponding displacement is zero.

· The displacement of a particle will be zero if that particle moves along a close path.
Because of the initial position and final position are coincided its displacement becomes zero however it has moved a certain distance the particle will have a significant amount of distance.

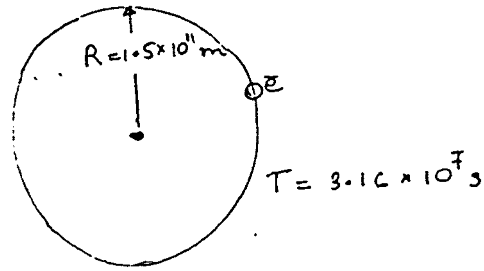
**
Q.2.16. Is the displacement always in the direction of motion?

No, the direction of displacement is not always the same as that of motion.
Since direction of motion is always pointed tangential to the path and the direction of displacement is directed from initial to final point, such two directions cannot be the same if a particle moves along a curve path.

Note.
Such two directions can be the same only when a particle moves along a straight path without back tracking. So, in general, the two directions is not always the same.

*

P 2.45. Find (a) the speed, and (b) the centripetal acceleration of the earth in its rotation around the sun. The radius of the earth's orbit is 1.5×10^{11} m and its period of revolution is 3.16×10^7 s.



We assumed that the orbit of the earth is a circle.

$$\text{The speed of earth} = \frac{\text{distance covered by the earth}}{\text{time elapsed}}$$

$$= \frac{\text{circumference}}{\text{time period}}$$

$$= \frac{2\pi R}{T}$$

$$= \frac{2 \times 3.142 \times 1.5 \times 10^{11}}{3.16 \times 10^{7}}$$

$$= 2.982 \times 10^{4} \ m s^{-1}$$

The centripetal acceleration $a_R = ?$

$$a_R = \frac{V^2}{R}$$

$$= \frac{(2.982 \times 10^{4})^2}{1.5 \times 10^{11}}$$

$$= 5.93 \times 10^{-3} \ m s^{-2}$$

*

P2.46. In Bohr's model of hydrogen atom, an electron revolves around a proton in a circular orbit radius 5.3×10^{-11} m with speed of 2.2×10^6 m s^{-1}. What is the acceleration of the electron in the hydrogen atom ?

Solution:

Since the electron revolves with constant speed, there will be no tangential acceleration. The only acceleration is that due to the change in direction of motion of the electron, the radial acceleration

$$R = 5.3 \times 10^{-11}\ m$$

$$V = 2.2 \times 10^{6}\ ms^{-1}$$

$$a_R = ?$$

$$a_R = \frac{V^2}{R}$$

$$= \frac{(2.2 \times 10^{6})^2}{5.3 \times 10^{-11}}$$

$$= 9.13 \times 10^{22}\ ms^{-2}$$

* P 2.43. A drill bit 0.25 inch in diameter is rotating at 1200 rpm. (a) What is the angular velocity ? (b) What is the linear velocity of a point on its circumference ?

Solution:

(a)

$$\omega = 1200 \text{ revolution per minute}$$

$$= 1200 \times \frac{2\pi \text{ radian}}{60 \text{ second}}$$

$$= 40\pi \text{ rad } s^{-1}$$

$\therefore$ angular velocity $\omega = 40\pi \text{ rad } s^{-1}$

(b)

$$V = r\omega$$

$$= \left(\frac{0.25 \text{ inch}}{2}\right) \times 40\pi = 5\pi \text{ inch per second}$$

$$= 15.71 \text{ inch per second}$$

$$= 1.31\ ft\ s^{-1}$$

Dynamic of a Particle

Q.3.6 *

A block is given a push along a tabletop, and slides off the table.(a)What force or forces are exerted on it while falling from the table to the floor? (b) What is the reaction to each force, that is, on what body and by what body is the reaction exerted? Neglect air resistance.

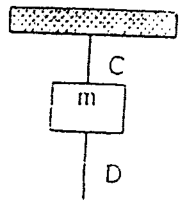
Answer.

(a) Whiling falling, only the gravitational force is exerted.

(b) The reaction here is the gravitational force exerted on the earth by the block.

Q-3.8 ***

A block of mass, m is supported by a cord C from the ceiling, and another cord D is attached to bottom of the block as shown in figure. Explain this; if you give a sudden jerk to D it will break, but if you pull on D steadily C will break.



HQ 8

Answer

A cord will break only after some amount of increase in its length (yielding) due to the applied force

When a sudden jerk is given to the cord D, because the time interval of the application of the fo is too short and if the mass (or inertia) of block is large enough to result in a small acceleration, the block will not move much. Then the cord D only will yield and break

When a steady pull is applied , because there is enough time for the block to move , both cords will yield . But since C is now under a larger tension – due to the weight of the block and the pulling force – it will yield more than D does and therefore break

Q 3-14 *

In the following statements choose the correct one. In real life, a moving body, left by itself, slows down and finally stops because

(a) "state of rest" is a natural state.

(b) a force is acting against the of motion.

(c) a net force is acting against the direction of motion

HQ 14

Answer

(c) a net force is acting against the direction of motion

Q 3-18 *

A heavily loaded truck is rolling along a straight level highway at 50 km h^{-1}. Must the driving force be equal to the resisting force, or must it be slightly greater in order to maintain the motion? Check your answer against Newton's first law of motion. Do you want to change your original answer? Or was your original answer correct?

The driving force must be equal to the total resisting force

According to Newton's law, "a moving body will continue moving with constant velocity if and when not force acts on it ". To maintin the motion , the truck has to be kept moving at constant velocity , and it requires a zero resultant force Thus a driving force which is equal and opposite to the resisting force is needed

Q. 3.15 *

A number of forces were known to be acting on a certain body; but, it is seen to remain the rest. What can you say about these forces?

The vector sum of forces are zero.