FOR GOD AND COUNTRY

ST. LAWRENCE HIGH SCHOOL

Pre- Annual Test – 2018

Sub: Physics **Class: XI-.** **F. M. : 70**

Duration: 3hrs 15 min **Date:21.02.2018**

Section – I

1. MCQ Questions each of 1 mark.(Answer all the question) **1x14=14**

i) The percentage error in the measurement of mass and speed are 2% and 3% respectively. The error in kinetic energy obtained by measuring mass and speed is

a) 12% b) 10% c) 8%. d) 5%.

ii) What will be the moment of inertia of a square lamina of side 'a' and mass 'm' about the axis XY as indicated in the figure? (the axis is lying in the plane of the lamina at its one end).

a) $\frac{m}{6}a^2$ b) $\frac{m}{3}a^2$ c) $\frac{m}{12}a^2$ d) $\frac{m}{4}a^2$

iii) A mass 1kg is suspended by a thread. It is – a)lifted with an acceleration of 4.9 m/s^2, b) lowered with an acceleration of 4.9 m/s^2. The ratio of tension in two cases is – (take g=9.8 m/s^2)

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

iv) If the Earth were to suddenly contract to $\frac{1}{n}$th of its present radius without any change of its mass, the duration of the new day will be

a) 24/n hrs b)24n hrs c) $\frac{24}{n^2}$ hrs d) $24\,n^2\ hrs$

v) when n identical small liquid drops form one single liquid drop at isolated condition –

a) *Temperature decreases*
b) Temperature increases
c) Temperature remain same
d) It first decreases, then increases.

vi) A 120g mass has a velocity $V = 4\hat{\imath} + 3\hat{\jmath}\ \ m/s$. Its kinetic energy will be

a) 1500 J b) 0.3 J c) 2.5 J d)1.5 J

vii) The displacement of a particle is given by the equation $S = 40 + 12t - t^3\ m$. How much distance does it travel before stop?

a) $16\ m$ b)$40\ m$ c) $56\ m$ d) 36 m

viii) If two vectors A and B are such that $|\vec{A}.\vec{B}| = |\vec{A} \times \vec{B}|$; then the angle between them will be –

a) 0^0 b) 45^0 c) 90^0 d) 180^0

ix) The radius of a soap bubble becomes twice as it rises up to upper surface from the bottom of a lake. If the atmospheric pressure is equal to the pressure exerted by water column of height H, then the depth of the lake will be –

a) H b)2 H c) 7H d) 8H

x) Two solid sphere of same metal having masses M and 8M respectively fall simultaneously through a viscous liquid and their terminal velocities become V and nV respectively. Then the value of n will be –

a) 4 b) 8 c) 16 d) 2

xi) If an oxygen atom and one hydrogen atom are having same temperature, then +66the ratio of their average kinetic energy will be –

a) 1 : 1 b)2 : 1 c) 4 : 1 d) 1 : 4

xii) A sample of gas expands from volume V_1 to V_2. The work done by the gas is greatest when the expansion is

a) Isothermal b) adiabatic c) isobaric d) equal in all cases.

xiii) A particle executes simple harmonic motion of amplitude A. The distance from the mean position where its kinetic energy is equal to its potential energy is –

a) 0.81 A b) 0.71 A c) 0.61 A d) 0.51 A

xiv) In a transverse progressive wave of amplitude A, the maximum particle velocity is 4 times its wave velocity. The wave length of the wave is –

a) $\frac{\pi A}{4}$ b) $\frac{\pi A}{2}$ c) πA d) $2\pi A$

Section – II

Group – A

Answer the following question in brief. (Alternatives are to be noted) 1x4=4

(For this group, mathematical explanation and diagrams are needed where applicable)

1. What will be the dimension of Young's modulus if velocity (V), acceleration (A) and force (F) are taken as fundamental quantity?
2. A ball is dropped from the top of a building while another is thrown horizontally at the same instant. Which ball will strike the ground first – why ?

   Or

   What are the maximum and minimum values of Poisson's ratio?
3. The earth is revolving round the sun. Is it an example of a simple Harmonic motion? Explain.
4. The wavelength of a travelling wave is 2m. What is the phase difference between two particles 1m apart in the path of the wave?

   Or

   At what temperature does a body stop radiating wave?

Group – B

Answer the following questions in short. (Alternatives are to be noted) 2x5 = 10

(For this group, mathematical explanations and diagrams are needed where applicable)

5. The position time relation of a moving particle is $x = 2t - 3t^3$. (x *is in metre and* t *is in second*).

   i) What is the maximum positive velocity of the particle? ii) When does the velocity of the particle become zero? 1+1

   Or

   Two non-collinear unit vectors $\hat{a}$ *and* $\hat{b}$ are such that $|\hat{a} + \hat{b}| = \sqrt{3}$. Find the angle between two vectors.
6. A block of mass 5kg rests on a table. 8N horizontal force is applied to push the block. Find out the force of friction between the block and the table. Given $\mu_s = 0.3$, $\mu_k = 0.2$ *and* $g = 10m/s^2$.

   Or

   A car of mass M moves up an inclined road making an angle θ with the horizontal with constant speed v. If μ is the coefficient of friction between the tyre of the car and the road, show that the power of the engine of the car is $P = vMg(sin\theta + \mu cos\theta)$.
7. Write Bernoulli's theorem in mathematical form and write down the meaning of each term used.

   Or

   What is Poisson's ratio? Why does it have no unit? 1+1

8. From the relation $P = \frac{1}{3}mnc^2$, show that the mean kinetic energy of a molecule is the same for all types of gases.

Or

One mole of ideal gas is compressed from state (P_1, V_1, T) to (P_2, V_2, T) isothermally. What is the change in internal energy of the gas?

9. The expression for standing wave is $y(x,t) = 2\sin(0.1\pi x)\cos(100\pi t)$, where x and y are in cm and t is in second. Find the distance between a node and the next anti-node of the wave.

Or

A particle situated in a homogeneous medium performs a simple harmonic oscillation of amplitude 3cm and frequency 25Hz. The velocity of the waves generated is 300cm/sec. Find the equation of the waves propagating in the positive direction of X-axis.

Group – C

Answer the following questions. (Alternatives are to be noted) 3x9=27

(For this group, mathematical explanations and diagrams are needed where applicable)

10. Two blocks A and B are placed side by side touching each other on a smooth horizontal table. Masses of the blocks are 3kg and 2kg respectively. Block A is pushed towards B with 10N horizontal force.

i) How much force does block A apply on block B?

ii) If A would apply the 10 N horizontal force on block B, what would be the applied force on block A? 1+2

Or

A particle of mass m moves in a circular path of radius r in a horizontal plane with uniform angular velocity ω about Z-axis. Write down the position vector of the particle at any instant and hence derive expressions for liner velocity and linear acceleration of the particle w.r.t ω. 1+1+1

11. A gun is mounted on a platform fitted with frictionless wheels. The mass of the platform with the gun, shells and the operator is 'M'. The gun fires shells one after another with a velocity 'v' in the horizontal direction. If mass of each shell is 'm', show that the recoil velocity of the platform after 'N' shells are fired, is $V_N = \frac{Nmv}{M-mN}$.

12. A particle moves from a position $\vec{r_1} = \hat{\imath} + 3\hat{\jmath}$ to $\vec{r_2} = 2\hat{\imath} + 4\hat{\jmath}$ in the influence of a force $\vec{F} = (3\hat{\imath} + 5\hat{\jmath})$ N. Find out the work done on the particle during the displacement. (Positions are given in meter.)

Or

What is a conservative force? Show that for conservative force, work done around a closed path zero. 1+2

13. Define angular momentum (L) and torque (τ). Show that $\frac{dL}{dt} = \tau$. 2+1

Or

i) State principle of conservation of angular momentum.

ii) A circular disc of mass M and radius R is rolling without slipping down an inclined plane of inclination θ with horizontal direction. Show that the acceleration of the centre of mass of the disc is $\frac{2}{3}g\sin\theta$. 1+2

14. i) Define centre of mass. ii) Two point masses 2g and 3g are situated at the locations (3cm, 5cm) and (4cm, 6cm) respectively. Find the position vector of centre of mass of two particles system.

15. Write Kepler's laws related to planetary motion.

Or

Find the expression for the potential energy and the kinetic energy of moon in the gravitational field of earth. Hence find the total energy of moon and state the significance of the sign in total energy expression. ½ +2+ ½

16. i) What do you mean by 'geo-stationary' satellite? ii) An artificial satellite of mass m is moving round the earth in an orbit of radius 2R (w.r.t earth's centre). How much work is to be done to transfer the satellite to an orbit of radius 4R? Will the potential energy of the satellite increase or decrease? (R= radius of earth.) 2 ½ + ½

Or

Define acceleration due to gravity. Derive an expression for the acceleration due to gravity at a place of latitude λ on the surface of the earth due to its rotation about its axis.

17. i) Write down Zeroth law of thermodynamics. ii) Explain, with reason, how do we arrive at the concept of temperature from this law. 1+2

Or

Define degrees of freedom and state the principle of equipartition of energy. Determine the number of degrees of freedom of an oxygen molecule at low temperature. 1+1+1

18. i) What is a heat engine? ii) Show the curves for adiabatic and isothermal processes on a single P-V diagram. 1+2

Or

Prove that $\gamma = 1 + \frac{2}{f}$. ($\gamma = ratio\ of\ two\ specific\ heats, f = no.\ of\ degrees\ of\ freedom\ of\ molecule$)

Group – D

Answer the following questions. (Alternatives are to be noted)

(For this group, mathematical explanations and diagrams are needed where applicable)

19. i) A body is moving from rest with an acceleration given by the equation $a = (3t + 4)\ m/s^2$. what will be its velocity in time 2 sec?

ii) A body is moving with uniform acceleration. Draw it's a) Velocity – time and b) Distance – time curve.

iii) Can a body have acceleration when its speed is constant? Explain. 2+2+1

Or

i) What is the importance of a null vector? ii) A train is moving with a velocity of 30km/h towards east and a car is moving with velocity 40km/h towards north. What will the velocity of car be as appears to a passenger in train? (Find out both magnitude and direction)

ii) If three vectors are such that $\vec{A} + \vec{B} + \vec{C} = 0$, prove that $\vec{A} \times \vec{B} = \vec{B} \times \vec{C} = \vec{C} \times \vec{A}$. 1+2+2

20. i) Draw stress – Strain curve for a metallic wire and show 'yield point' and 'fracture point'.

ii) If a number of little water droplets, each of radius r, coalesce to form a single drop of radius R, show that the rise in temperature will be equal to $\frac{3S}{J}\left(\frac{1}{r} - \frac{1}{R}\right)$ $in\ C.G.S\ system.$ Consider the density and specific heat of water in C.G.S system as 1gm/cc and 1cal/gm-^{0}C respectively. 2+3

Or

i) Define Absorptive power and Emissive power of a body. ii) Write down Kirchhoff's law of heat radiation.

iii) A spherical body with radius 12cm radiates 450W power at 500K. If the radius were halved and the temperature doubled, what would be the power radiated? (1+1)+1+2

21. i) What do you mean by 'Quasi-Static process'?

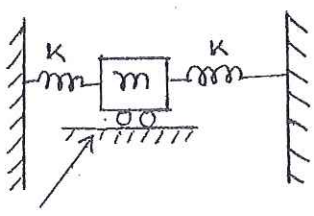
ii) Write down two differences between 'Isothermal process' and 'Adiabatic process'.

iii) Five moles of an ideal gas is taken in a Carnot engine working between 100^{0}C and 30^{0}C. The useful work-done in one cycle is 420J. Calculate the amount of heat absorbed from the source and amount of heat released to the sink.(1+2+2)

Or

i) Prove that for a simple harmonic motion, the total energy is conserved (in the absence of any frictional force).

ii) Find out the time period of oscillation of the spring-mass system as shown in the figure. 3+2



Soumitra Maity.
23.02.18

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Section – I

1. MCQ Questions each of 1 mark.(Answer all the question) **1x14=14**

i) c) 8%.

ii) b) $\frac{m}{3}a^2$

iii) a) 3 : 1

iv) c) $\frac{24}{n^2}$ hrs

v) b)Temperature increases

vi) d)1.5 J

vii) a) 16 m

viii) b) 45^0

ix) c) 7H

x) a) 4

xi) A) 1 : 1

xii) c) isobaric

xiii) b) 0.71 A

xiv) **b)** $\frac{\pi A}{2}$

Section – II

Group – A

Answer the following question in brief. (Alternatives are to be noted) **1x4=4**

(For this group, mathematical explanation and diagrams are needed where applicable)

1. **What will be the dimension of Young's modulus if velocity (V), acceleration (A) and force (F) are taken as fundamental quantity?**

Ans: we know, $Y = \frac{F/Area}{L/l}$

So, [Y]=[F/Area] {as L/l is dimensionless }

Now, [Area]=[length x length] = [velocity x time]^2=[velocity x $\frac{Velocity}{Acceleration}$]^2 = $V^4\ A^{-2}$

So, [Y] = F $V^4\ A^{-2}$

2. **A ball is dropped from the top of a building while another is thrown horizontally at the same instant. Which ball will strike the ground first – why ?**

Ans: Both will take equal amount of time to strike the ground.

If we consider the motion of the ball which is thrown horizontally with some initial velocity, then we get the ball is having no vertical component of initial velocity. So the horizontal motion of this ball will be same as the ball dropped.

Or

What are the maximum and minimum values of Poisson's ratio?

Ans: *Theoretically* $-1 < \sigma < 0.5$ *but practically its value lies between* 0 *and* 0.5

3. **The earth is revolving round the sun. Is it an example of a simple Harmonic motion? Explain.**

Ans: No, it is an example of periodic motion but it is not SHM. To be an SHM there should be one mean position about which the system vibrates and there should be a retarding force that is directly proportional to the displacement from the mean position. In cae of Earth's rotation, these conditions are not satisfied.

4. **The wavelength of a travelling wave is 2m. What is the phase difference between two particles 1m apart in the path of the wave?**

Ans: so, $\lambda = 2\ m$

Phase difference $= \frac{2\pi}{\lambda} \times path\ difference = \frac{2\pi}{2} \times 1 = \pi.$

Or

At what temperature does a body stop radiating wave?

Ans: At 0K

Group – B

Answer the following questions in short. (Alternatives are to be noted) 2x5 = 10

(For this group, mathematical explanations and diagrams are needed where applicable)

5. **The position time relation of a moving particle is $x = 2t - 3t^3$. (x is in metre and t is in second).**

i) What is the maximum positive velocity of the particle? ii) When does the velocity of the particle become zero? 1+1

Ans: $x = 2t - 3t^3$

So $v = 2 - 9t^2\ m/sec$

i) Hence the maximum positive velocity will be 2m/sec

ii) If $v = 0\ then\ we\ have,\ \ 2 - 9t^2 = 0$

$or, t = \frac{\sqrt{2}}{3}\ sec$

Or

Two non-collinear unit vectors $\hat{a}$ and $\hat{b}$ are such that $|\hat{a} + \hat{b}| = \sqrt{3}$. Find the angle between two vectors.

Ans: Given, $|\hat{a} + \hat{b}| = \sqrt{3}$

Or, $\sqrt{(a^2 + b^2 + 2ab\ cos\theta)} = \sqrt{3}$

$a^2 + b^2 + 2ab\ cos\theta = 3$

Or, $1 + 1 + 2\ cos\theta = 3$ $\{as\ \hat{a}, \hat{b}\ are\ the\ unit\ vectors\}$

Or, $cos\theta = \frac{1}{2}$

$or,\ \theta = 60^0$

6. **A block of mass 5kg rests on a table. 8N horizontal force is applied to push the block. Find out the force of friction between the block and the table. Given $\mu_s = 0.3,\ \mu_k = 0.2$ and $g = 10m/s^2$.**

Ans: the normal reaction force N = 5 x 10 Newton = 50 Newton

So the maximum frictional force = N x μ_s = 50 x 0.3 = 15 Newton

i.e. force required to move the block will be minimum 15 Newton.

As the applied force is less than the minimum force required to move the block, so the frictional force will be equal to the applied force i.e. 8 Newton.

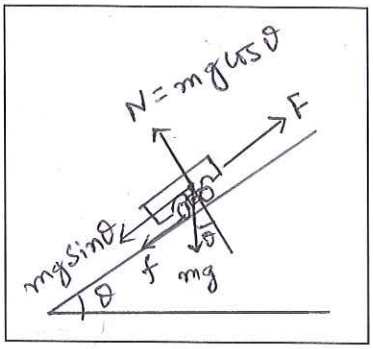
Or

A car of mass M moves up an inclined road making an angle θ with the horizontal with constant speed v. If μ is the coefficient of friction between the tyre of the car and the road, show that the power of the engine of the car is $P = vMg(sin\theta + \mu cos\theta)$.

Ans:

As the car is moving up, the downward forces = component of its weight + frictional force

$= Mg\sin\theta + Mg\mu\cos\theta. = Mg(\sin\theta + \mu\cos\theta).$



As the car is moving with zero acceleration,

So, upward force by which the car moves = total downward force.

i.e. upward force by which the car moves $= Mg(\sin\theta + \mu\cos\theta)$.

Power $= \frac{work}{time} = \frac{force \times displacement}{time} = force \times velocity$

So the powr of the engine $= Mg(\sin\theta + \mu\cos\theta) \times v$

$= vMg(\sin\theta + \mu\cos\theta)$ $\{proved\}$

7. **Write Bernoulli's theorem in mathematical form and write down the meaning of each term used.**

Ans: Refer to any standard text book.

Or

What is Poisson's ratio? Why does it have no unit?

Ans: Refer to any standard text book.

1+1

8. **From the relation $P = \frac{1}{3}mnc^2$, show that the mean kinetic energy of a molecule is the same for all types of gases.**

Ans: Refer to any standard text book.

Or

One mole of ideal gas is compressed from state (P_1, V_1, T) to (P_2, V_2, T) isothermally. What is the change in internal energy of the gas?

Ans: we know temperature is the measure of internal energy of any thermodynamic system. As the temperature is not changing, so there will not be any change of internal energy.

9. **The expression for standing wave is $y(x,t) = 2\sin(0.1\pi x)\cos(100\pi t)$, where x and y are in cm and t is in second. Find the distance between a node and the next anti-node of the wave.**

Ans: comparing with the general equation of a standing wave $y(x,t) = 2a\sin\left(\frac{2\pi x}{\lambda}\right)\cos\left(\frac{2\pi vt}{\lambda}\right)$ we get,

$\frac{2\pi}{\lambda} = 0.1\pi$

$or, \lambda = 20\ cm$

So, the distance between a node and next anti node is $= \frac{\lambda}{4} = \frac{20}{4}cm = 5\ cm$

Or

A particle situated in a homogeneous medium performs a simple harmonic oscillation of amplitude 3cm and frequency 25Hz. The velocity of the waves generated is 300cm/sec. Find the equation of the waves propagating in the positive direction of X-axis.

Ans: the general equation for plane progressive wave travelling along positive X direction is $y(x,t) = a\ \sin\frac{2\pi}{\lambda}(vt - x)$

Given, $a = 3cm,\ v = 300cm/s$ and $f = 25Hz$.

So $\lambda = \frac{v}{f} = \frac{300}{25} = 12cm$

Hence the wave equation becomes, $y(x,t) = a\ \sin\frac{2\pi}{\lambda}(vt - x) = 3\ \sin\frac{2\pi}{12}(300t - x)$

Or, $y(x,t) = 3\ \sin\frac{\pi}{6}(300t - x)$

Group – C

Answer the following questions. (Alternatives are to be noted) 3x9=27

(For this group, mathematical explanations and diagrams are needed where applicable)

10. **Two blocks A and B are placed side by side touching each other on a smooth horizontal table. Masses of the blocks are 3kg and 2kg respectively. Block A is pushed towards B with 10N horizontal force.**

i) **How much force does block A apply on block B?**

ii) **If A would apply the 10 N horizontal force on block B, what would be the applied force on block A?** 1+2

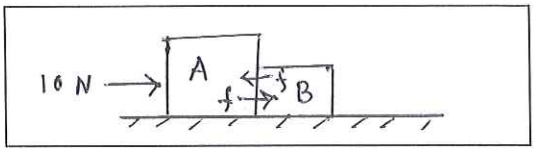
Ans: i) the common acceleration $a = \frac{10}{3+2} m/s^2 = 2\ m/s^2$

Let block A apply 'f' amount of force on block –B, then block-B also apply same 'f' amount of force on block-A .

Considering the free body diagram of block- A,

We get, $10 - f = 3 \times 2$

$or, f = 4\ Newton.$ so block-A applies 4 Newton force on block-B.



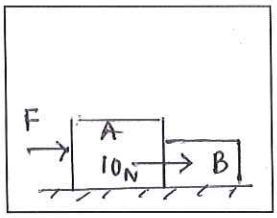
ii)For this case let F amount of force is applied on block –A. If A is applying 10N force on block-B, then it will get back 10N reaction force from block –B.

Also the acceleration of both the blocks will be same as they are remaining in contact.

So, acceleration of block A = acceleration of block B = $\frac{force\ on\ block\ B}{mass\ of\ block\ B} = \frac{10}{2} = 5m/s^2$

then considering the free body diagram of block A, we have

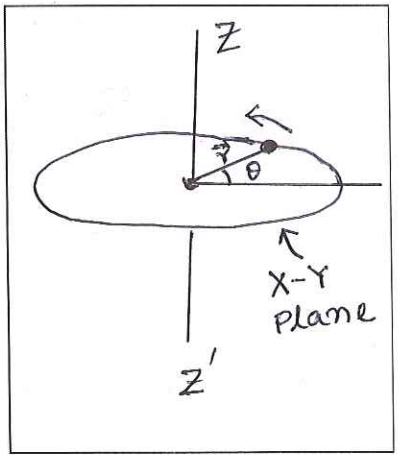
$F - 10 = mass\ of\ block\ A \times acceleration\ of\ block\ A = 3 \times 5 = 15\ N$



Or

A particle of mass m moves in a circular path of radius r in a horizontal plane with uniform angular velocity ω about Z-axis. Write down the position vector of the particle at any instant and hence derive expressions for liner velocity and linear acceleration of the particle w.r.t ω . 1+1+1

Ans: Let, at an instant the angular position of the particle w.r.t a chosen initial position be θ as shown in the fig.



Then, the X-component of the position vector will be = $rcos\theta$

And the Y component of the position vector will be = $rsin\theta$

*** So the position vector wil be $\vec{r} = rcos\theta\ \hat{\imath} + rsin\theta\ \hat{\jmath} = r(cos\theta\ \hat{\imath} + sin\theta\ \hat{\jmath})$

*** The linear velocity $\vec{V} = \frac{d\vec{r}}{dt} = \frac{d}{dt}\{r(cos\theta\ \hat{\imath} + sin\theta\ \hat{\jmath})\}$

$= r\left(-\frac{d\theta}{dt} sin\theta\ \hat{\imath} + \frac{d\theta}{dt} cos\theta\ \hat{\jmath}\right)$ {remember here r = constant as its being the radius of the circular path.}

So, $\vec{V} = \omega r(-sin\theta\ \hat{\imath} + cos\theta\ \hat{\jmath})$ {as $\frac{d\theta}{dt} = \omega$}

*** so the acceleration will be

$\vec{a} = \frac{d\vec{V}}{dt} = \omega^2 r(-cos\theta\ \hat{\imath} - sin\theta\ \hat{\jmath}) = -\omega^2 r(cos\theta\ \hat{\imath} + sin\theta\ \hat{\jmath}) = -\omega^2 \vec{r}$

11. **A gun is mounted on a platform fitted with frictionless wheels. The mass of the platform with the gun, shells and the operator is 'M'. The gun fires shells one after another with a velocity 'v' in the horizontal direction. If mass of each shell is 'm', show that the recoil velocity of the platform after 'N' shells are fired, is $V_N = \frac{Nmv}{M-mN}$.**

Ans: Let V_1 be the recoil velocity of platform after the 1st bullet is fired.

Then, from the conservation of linear momentum, we get –

$(M - m)V_1 - mv = 0$

Or, $V_1 = \frac{mv}{M-m}$.

So, after the 1st bullet is fired, the platform starts moving with this velocity V_1.

After the 2nd bullet is fired, let V_2 be the recoil velocity of the platform

Then, $(M - 2m)V_2 - mv = (M - m)V_1 = mv$ $\{putting\ the\ value\ of\ V_1\}$

Or, $V_2 = \frac{2mv}{M-2m}$

Similarly we will get the recoil velocity after 3rd bullet is fired as $V_3 = \frac{3mv}{M-3m}$

SO, after N bullets are fired, the recoil velocity will be $V_N = \frac{Nmv}{M-Nm}$.

12. **A particle moves from a position $\overrightarrow{r_1} = \hat{\imath} + 3\hat{\jmath}$ to $\overrightarrow{r_2} = 2\hat{\imath} + 4\hat{\jmath}$ in the influence of a force $\vec{F} = (3\hat{\imath} + 5\hat{\jmath})$ N. Find out the work done on the particle during the displacement. (Positions are given in meter.)**

Ans: the displacement = $\vec{r} = \overrightarrow{r_2} - \overrightarrow{r_1} = \hat{\imath} + \hat{\jmath}$

so, the work done = $\vec{F}.\vec{r} = (3 + 5) = 8J$

Or

What is a conservative force? Show that for conservative force, work done around a closed path zero. 1+2

Ans: refer to any standard text book.

13. **Define angular momentum (L) and torque (τ). Show that $\frac{dL}{dt} = \tau$.** 2+1

Ans: refer to any standard text book.

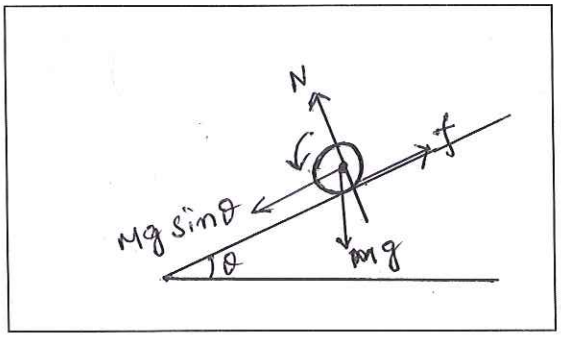
Or

i) **State principle of conservation of angular momentum.**

ii) **A circular disc of mass M and radius R is rolling without slipping down an inclined plane of inclination θ with horizontal direction. Show that the acceleration of the centre of mass of the disc is $\frac{2}{3}gsin\theta$.** 1+2

Ans: i) refer to any standard text book.

ii) Let, frictional force, that causing rolling motion by creating the torque, be f.
the angular acceleration be α, the moment of inertia be I and linear acceleration of CM of disc be a.



$Then, torque = f \times R = I \times \alpha = \frac{Ia}{R}$

Or, $f = \frac{Ia}{R^2}$ ……(1)

Now the equation of motion of CM of the body will be

$Mgsin\theta - f = Ma$

Or, $Mgsin\theta - \frac{Ia}{R^2} = Ma$ {by relation (1)}

Or, $Mgsin\theta - \frac{1}{2}Ma = Ma$ {as $I = \frac{1}{2}MR^2$ *for disc*}

Or, $\frac{3}{2}Ma = Mgsin\theta$

Or, $a = \frac{2}{3}gsin\theta$

14. **i) Define centre of mass. ii) Two point masses 2g and 3g are situated at the locations (3cm, 5cm) and (4cm, 6cm) respectively. Find the position vector of centre of mass of two particles system.**

Ans: $X_{CM} = \frac{2 \times 3 + 3 \times 4}{2+3} = \frac{18}{5}\ cm$

and, $Y_{CM} = \frac{2 \times 5 + 3 \times 6}{2+3} = \frac{28}{5}\ cm$

hence the position vector will be $\vec{r} = \frac{18}{5}\hat{\imath} + \frac{28}{5}\hat{\jmath}$

15. **Write Kepler's laws related to planetary motion.**

Ans: Refer to any standard text book.

Or

Find the expression for the potential energy and the kinetic energy of moon in the gravitational field of earth. Hence find the total energy of moon and state the significance of the sign in total energy expression. ½ +2+ ½

Ans: Refer to any standard text book.

16. i) **What do you mean by 'geo-stationary' satellite? ii) An artificial satellite of mass m is moving round the earth in an orbit of radius 2R (w.r.t earth's centre). How much work is to be done to transfer the satellite to an orbit of radius 4R? Will the potential energy of the satellite increase or decrease? (R= radius of earth.)** 2 ½ + ½

Ans: ii)Let M be the mass of earth and m be the mass of satellite.

The total energy of the satellite in an orbit of radius r is E = $-\frac{GMm}{2r}$

So, its total energy when it is in the orbit of radius 2R is $E_1 = -\frac{GMm}{4R}$

And when it is in the orbit of radius 4R, the total energy $E_2 = -\frac{GMm}{8R}$

So, the work done needed to send it = $E_2 - E_1 = -\frac{GMm}{8R} - \left(-\frac{GMm}{4R}\right) = \frac{GMm}{8R}$

*** The potential energy increases with distance and becomes maximum at infinity with the value zero. So, the potential energy of satellite will increase.

Or

Define acceleration due to gravity. Derive an expression for the acceleration due to gravity at a place of latitude λ on the surface of the earth due to its rotation about its axis.

Ans: Refer to any standard text book.

17. i) **Write down Zeroth law of thermodynamics. ii) Explain, with reason, how do we arrive at the concept of temperature from this law.** 1+2

Ans: Refer to any standard text book.

Or

Define degrees of freedom and state the principle of equipartition of energy. Determine the number of degrees of freedom of an oxygen molecule at low temperature. 1+1+1

Ans: Refer to any standard text book.

18. **i) What is a heat engine? ii) Show the curves for adiabatic and isothermal processes on a single P-V diagram.** 1+2

Ans: Refer to any standard text book.

Or

Prove that $\gamma = 1 + \frac{2}{f}$. ($\gamma = ratio\ of\ two\ specific\ heats, f = no.of\ degrees\ of\ freedom\ of\ molecule$)

Ans: Refer to any standard text book.

Group – D

Answer the following questions. (Alternatives are to be noted)

(For this group, mathematical explanations and diagrams are needed where applicable)

19. i) **A body is moving from rest with an acceleration given by the equation $a = (3t + 4)\ m/s^2$. what will be its velocity in time 2 sec?**

ii) A body is moving with uniform acceleration. Draw it's a) Velocity – time and b) Distance – time curve.

iii) Can a body have acceleration when its speed is constant? Explain. 2+2+1

Ans: i) The velocity $v = \int_{t=0}^{2} a\,dt = \int_{t=0}^{2}(3t + 4)\,dt = 3\left[\frac{t^2}{2}\right]_0^2 + 4[t]_0^2 = 6 + 8 = 14\ m/s$

ii)see any standard text book.

iii)yes, in case of uniform circular motion the speed remains same but the direction changes all the time and so the velocity, and we get an acceleration as it is nothing but the rate of change of velocity.

Or

i) **What is the importance of a null vector? ii) A train is moving with a velocity of 30km/h towards east and a car is moving with velocity 40km/h towards north. What will the velocity of car be as appears to a passenger in train? (Find out both magnitude and direction)**

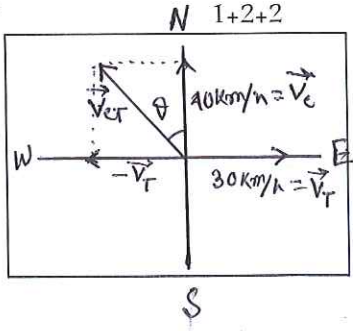
ii) **If three vectors are such that $\vec{A} + \vec{B} + \vec{C} = 0$, prove that $\vec{A} \times \vec{B} = \vec{B} \times \vec{C} = \vec{C} \times \vec{A}$.** 1+2+2

Ans i) Null vector is the additive identity element in vector field.

Relative velocity of Car w.r.t a passenger in Train = $\vec{V}_{CT} = \vec{V}_C - \vec{V}_T = \vec{V}_C + (-\vec{V}_T)$

so the velocity of car as appeared to a person in train = $\sqrt{40^2 + 30^2} = 50\ km/h$

and the direction will be $\theta = \tan^{-1}\left(\frac{3}{4}\right)$ west of north.



ii)Given, $\vec{A}+\vec{B}+\vec{C}=0$

$\vec{A}\times(\vec{A}+\vec{B}+\vec{C})=\vec{A}\times 0$

Or, $\vec{A}\times\vec{B}+\vec{A}\times\vec{C}=0$ $\{as\ \vec{A}\times\vec{A}=0\}$

Or, $\vec{A}\times\vec{B}-\vec{C}\times\vec{A}=0$

Or, $\vec{A}\times\vec{B}=\vec{C}\times\vec{A}$ ..... (1)

Also, $\vec{A}+\vec{B}+\vec{C}=0$

Or, $\vec{B}\times(\vec{A}+\vec{B}+\vec{C})=\vec{B}\times 0$ $\{as\ \vec{B}\times\vec{B}=0\}$

Or, $\vec{B}\times\vec{A}+\vec{B}\times\vec{C}=0$

Or, $\vec{B}\times\vec{C}=-\vec{B}\times\vec{A}$

Or, $\vec{B}\times\vec{C}=\vec{A}\times\vec{B}$ ..... (2)

Now, comparing equation (1) and (2) we can conclude $\vec{A}\times\vec{B}=\vec{B}\times\vec{C}=\vec{C}\times\vec{A}$

20. **i) Draw stress – Strain curve for a metallic wire and show 'yield point' and 'fracture point'.**

ii) If a number of little water droplets, each of radius r, coalesce to form a single drop of radius R, show that the rise in temperature will be equal to $\frac{3S}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$ *in C.G.S system*. Consider the density and specific heat of water in C.G.S system as 1gm/cc and 1cal/gm-^{0}C respectively. 2+3

Ans: i)Refer to any standard text book.

ii)Let n number of droplets form a single drops.

So, $n\times\frac{4}{3}\pi r^3=\frac{4}{3}\pi R^3$

Or, $nr^3=R^3$ ..... (1)

The decrease in surface energy = increase in heat energy.

Or, $S\times\{n\times 4\pi r^2-4\pi R^2\}=J\times mass\ of\ single\ drop\times specific\ heat\times rise\ in\ temperature$

Or. $S\left\{\frac{R^3}{r^3}\times 4\pi r^2-4\pi R^2\right\}=J\times\frac{4}{3}\pi R^3\times 1\times\Delta t$ $\left\{from\ (1) we\ get, n=\frac{R^3}{r^3}\right\}$

Or, $\Delta t=\frac{3}{4\pi JR^3}\times S\times 4\pi R^2\left(\frac{R}{r}-1\right)$

Or, $\Delta t=\frac{3S}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$

Or

i) **Define Absorptive power and Emissive power of a body. ii) Write down Kirchhoff's law of heat radiation.**

iii) **A spherical body with radius 12cm radiates 450W power at 500K. If the radius were halved and the temperature doubled, what would be the power radiated?** (1+1)+1+2

Ans: i) refer to any standard book.

ii)we know the radiated power, $E=A\sigma T^4$

for, spherical body-

$E=4\pi r^2\sigma T^4$

So, $\frac{E_2}{E_1}=\left(\frac{r_2}{r_1}\right)^2\left(\frac{T_2}{T_1}\right)^4=\left(\frac{1}{2}\right)^2(2)^4=\frac{1}{4}\times 16=4$

So, $E_2=4E_1=4\times 450\ W=1800\ W$

21. i) **What do you mean by 'Quasi-Static process'?**

ii) Write down two differences between 'Isothermal process' and 'Adiabatic process'.

iii) Five moles of an ideal gas is taken in a Carnot engine working between 100°C and 30°C. The useful work-done in one cycle is 420J. Calculate the amount of heat absorbed from the source and amount of heat released to the sink.

(1+2+2)

Ans: i) Refer to any standard book.

ii) Refer to any standard book.

iii)Here $T_1 = 100 + 273 = 373K$

and $T_2 = 30 + 273 = 303K$

useful work done in one cycle = 420J

i.e. $W = Q_1 - Q_2 = 420J$ .....(1)

also $\frac{Q_1}{Q_2} = \frac{T_1}{T_2} = \frac{373}{303}$

or, $Q_1 = \frac{373}{303} Q_2$ ..... (2)

solving (1) and (2)

we get, $Q_1 = 2238\,J$ *and* $Q_2 = 1818\,J$

Or

i) **Prove that for a simple harmonic motion, the total energy is conserved (in the absence of any frictional force).**

ii) **Find out the time period of oscillation of the spring-mass system as shown in the figure.** 3+2

Ans: i)Refer to any standard text book.

ii)the springs are in parallel connection. The equivalent spring constant = K + K = 2K

so the time period $T = 2\pi\sqrt{\frac{m}{2K}}$