M. Nyngi 7/8/19

ST. LAWRENCE HIGH SCHOOL
FIRST TERM – 2019

FOR GOD AND COUNTRY

Sub : PHYSICS (NEW SYLLABUS) **Class : XI A1** **F.M. : 70**
Duration : 3 hours 15 minutes **SOLUTION** **Date : 01.08.2019**

SECTION – I

Answer the following questions (Multiple choice questions) : [1x14=14]

(1) Which of the following is dimensionally correct? Ans: (a) Pressure = energy per unit volume

(2) The displacement of a particle starting from rest (t = 0) is given by $s = 6t^2 - t^3$. The time in second at which the particle obtain zero velocity again is: Ans: (b) 4

(3) Find the torque of a force $\vec{F} = -3\hat{\imath} + 2\hat{\jmath} + \hat{k}$ acting at the point $\vec{r} = 8\hat{\imath} + 2\hat{\jmath} + 3\hat{k}$: Ans: (d) $-4\hat{\imath} - 17\hat{\jmath} + 22\hat{k}$

(4) A particle is projected from the surface of the earth with a speed of 20 ms^{-1} at an angle 30° with the horizontal.The range of that particle is: Ans: (c) $20\sqrt{3}$ m

(5) The working principle of a jet engine is based on the principle of :Ans: (c) Conservation of linear momentum

(6) A cricket ball of mass 0.5 kg moving at 30 ms^{-1} hits a bat perpendicualr and rebounces with a velocity of 20 ms^{-1}. Impulse of the force exerted by the ball on the bat is : Ans: (c) 25 Ns

(7) Consider an elevator moving downwards with an acceleration a, the force exerted by a passenger of mass m in the floor of the elevatr is : Ans: (c) $mg - ma$

(8) A piece of stone of mass 1 kg slides over ice at 2 ms^{-1} and comes to rest in 10 s. In this case the frictional force is: Ans: (a) 0.2 N

(9) A body of mass m is pushed up with a velocity u along a plane of inclination θ. If the coefficient of friction between the body and the inclined plane is μ , displacement of the body before coming to rest is: Ans: (c) $\frac{u^2}{4g \sin\theta}$

(10) Angular velocity of the hour hand of a clock is :Ans : (c) $\frac{\pi}{21600}$ rad s^{-1}

(11) If a body travels along a circular path with uniform speed then its acceleration. Ans: (c) Acts along its radius

(12) Power required to raise a mass of 120 kg vertically upwards at a velocity of 4.5 ms^{-1} is : Ans: (b) 5.3 kW

(13) A particle is moving in a straight line such that its retardation is directly proportional to its displacement. Decrease in the kinetic energy of the body is directly proportional to: Ans: (a) x^2

(14) A force acts on a particle of mass 3 kg, such that the position of the particle changes with time as per the equation $x = 3t - 4t^2 + t^3$. If we express x in m and t in s, work done in 4 s will be : Ans: (d) 576 mJ

SECTION – II

GROUP – A

Answer the following questions in one sentence (Alternatives are to be noted):[1 x 4 = 4]

(1) If $\vec{A} \cdot \vec{B} = \vec{A} \cdot \vec{C}$ then can we conclude that $\vec{A} = \vec{C}$? Ans: NO

OR

What is the difference between angstrom unit and astronimical unit (AU)?

Ans: 1 angstrom unit (Å) = 10^{-10} m and 1 astronimical unit (AU) = 1.496×10^{11} m

(2) Why is centrifugal force called pseudo force?

Ans: To an observer situated in a reference frame rotating in a circular path, a pseudo force seems to act on a body which arises only due to the centripetal acceleration of the reference frame. This force which seems to act on the body in a direction opposite to that of the said acceleration that is radially outwards is called the cenrifugal force. Its magnitude is $m\omega^2 r$ or mv^2/r that is equal to that of the centripetal force.

(3) Can a body moving with uniform speed have variable velocity?

Ans: Yes, when the body is moving in a circle.

(4) How will the kinetic energy of the body change if its momentum is doubled?

Ans: $p = \sqrt{2mE_k}$ or $E_k = p^2/2m$ Thus when the momentum (p) is doubled then the kinetic energy E_k becomes four times.

GROUP – B

Answer the following questions in short (Alternatives are to be noted): [2 x 5 = 10]

(5) If $\vec{A} = 10\hat{\imath} - 15\hat{\jmath} - 20\hat{k}$ and $\vec{B} = 6\hat{\imath} + 8\hat{\jmath} - 12\hat{k}$, find $\vec{A} \cdot \vec{B}$ and the angle between $\vec{A}$ and $\vec{B}$.

Ans: $\vec{A} \cdot \vec{B} = (10\hat{\imath} - 15\hat{\jmath} - 20\hat{k}) \cdot (6\hat{\imath} + 8\hat{\jmath} - 12\hat{k}) = 180$

$\cos\theta = \frac{\vec{A}\cdot\vec{B}}{AB} = \frac{180}{\sqrt{10^2+15^2+20^2}\sqrt{6^2+8^2+12^2}} = 0.428$ or, $\theta = \cos^{-1} 0.428 = 64°40'$

(6) What is the dimension of force? A body moves under the action of a force. If at a certain moment the force be removed, will the body stop?

Ans: $[MLT^{-2}]$. The body may move with uniform velocity.

(7) State Work-Energy Theorem. Is the resistance due to air a conservative force.

Ans: When the work done on a particle is equal to the change in its kinetic energy. NO.

OR

What is no-work force? Explain.

Ans: When the force is perpendicular to the displacement W = FS cos θ = FS cos 90° = 0. So its no-work force.

(8) Prove $v^2 = u^2 + 2as$ by calculus method.

Ans: $a = dv/dt = dv/ds \times ds/dt = vdv/ds$ or, $ads = v\,dv$

Intrigrating: $\int_0^s ads = \int_u^v vdv$ or, $as = v^2/2 - u^2/2$ or $v^2 = u^2 + 2as$

(9) Dimensionally prove the expression for the centripetal force F acting on a particle of mass m, moving with velocity v in a circle of radius r.

Ans: Dimension of $mv^2/r = [M][L^2T^{-2}]/[L] = [MLT^{-2}]$ = dimension of centripetal force

GROUP – C

Answer the following questions in short (Alternatives are to be noted): [3 x 9 = 27]

(10) Two forces P and Q acting at a poitn have a resultant equal to $\sqrt{3}$ Q making an angle 30° with the direction of P. Prove that either P = Q or P = 2Q.

Ans: θ be the angle between P and Q. resolving them the resultant is $\sqrt{3}$ Q and force Q along direction of P and perpendicular to it we have,

Q sin $\theta = \sqrt{3}$ Q sin 30° or, sin $\theta = \sqrt{3} \times \frac{1}{2} = \sin 60°$ or, $\theta = 60°$

P$\pm$Q cos $\theta = \sqrt{3}$ Q cos 30° or, P$\pm$Q cos 60° $= \sqrt{3}$ Q cos 30° or, P$\pm$Q x $\frac{1}{2} = \sqrt{3}$ Q $\frac{\sqrt{3}}{2}$

or, P $= \frac{3}{2}$ Q $\pm \frac{1}{2}$ Q Thus, P = Q or P = 2Q

(11) If a shower of rain appears to be falling vertically downwards with a speed of 12 kmhr^{-1} to a person walking due east with a speed of 5 kmhr^{-1}, what is the actual direction of the rain?
Ans: If the rain makes an angle θ with the vertical then tan θ = 5/12 = 0.417 and $\theta = \tan^{-1} 0.417 = 22°37'$ west of vertical.

OR

Can the passengers sitting inside a stationary car move the car by pushing it from inside? Explain.
Ans: Force should be external and unbalanced.

(12) Show that the trajectory of the projectile is parabolic.
Ans: [Diagram may be given] $u_x = u \cos \theta$ along horizontal axis; $u_y = u \sin \theta$ along vertical axis
Acceleration $a_x = 0$ and $a_y = -g$ At any pint P(x,y) and at any time t : $x = u_x t = u t \cos \theta$ or, t = x/ucos θ and $y = u_y t + \frac{1}{2} a_y t^2 = ut \sin \theta - \frac{1}{2} gt^2$
Thus equation of the trajectory of the projectile $y = u \sin \theta \, (x/u\cos \theta) - \frac{1}{2} gx^2/u^2\cos^2 \theta = x \tan \theta - (g/2u^2\cos^2 \theta) x^2$
This is an equation of parabola. Thus the trajectory of the projectile is parabolic.

(13) Find the angle of projection for a projectile motion whose range R is n times the maximum height H.
Ans: R = nH or $\frac{u^2 sin2\theta}{g} = n\frac{u^2 sin^2\theta}{2g}$ or, tan θ = 4/n or $\theta = \tan^{-1}(4/n)$

(14) A force of 1.00 x 10^{-3} N acts on a mass of 10 x 10^{-3} kg for 5 sec. Find the change of momentum during the time.
Ans: Acceleration = force / mass = 1.00 x 10^{-3} N/10 x 10^{-3} kg = 0.1 ms^{-2}
Change in velocity = acceleration x time = 0.1 ms^{-2} x 5 s = 0.5 ms^{-1}
Thus change in momentum =mass x change in velocity = 10 x 10^{-3}kg x 0.5ms^{-1} = 5 x 10^{-3}kgms^{-1}
Or, Change in momentum = force x time = 1.00 x 10^{-3} N x 5 s = 5 x 10^{-3}kgms^{-1}

(15) A body is placed on a plane inclined at 45° with the horizontal. Starting from rest, the body acquired a velocity of 2 ms^{-1} after sliding through a distance of 36.4 cm. Find the coefficient of friction between the body and the plane.
Ans: mgsin θ - f = ma or, mgsin $\theta - \mu_s$ mgcos θ = ma or, gsin $\theta - \mu_s$ gcos θ = a
For $\theta = 45°$, sin 45° = cos 45° = $1/\sqrt{2}$ and for g = 9.8 ms^{-2}
Also, $v^2 = u^2 + 2as$ or, $a = v^2/2s = 2^2/(2x\ 0.364)$
$9.8 \times 1/\sqrt{2} - \mu_s 9.8 \times 1/\sqrt{2} = 2^2/(2x\ 0.364)$ or, $\mu_s = 0.207$

(16) What is the loss of potential energy of a freely falling body of mass m, during the tth second.
Ans: If the body starts from rest u = 0,
Displacement in t sec is $x = gt^2/2$
Displacement in (t – 1) sec, $y = g(t-1)^2/2$
Displacement in tth sec, $h = x - y = gt^2/2 - g(t-1)^2/2 = g(2t-1)/2$
Decrease in potential energy in tth sec = mgh = mg[g(2t – 1)/2] = $mg^2(2t-1)/2$

(17) A constant force $\vec{F} = (-\hat{\imath} + 2\hat{\jmath} + 3\hat{k})$ N acts on a body. How much work is to be done to move the body first through a distance 4 m along z –axis and then 3 m along y-axis?
Ans: Work done = $\vec{F} \cdot \vec{S} = = (-\hat{\imath} + 2\hat{\jmath} + 3\hat{k}) \cdot (3\hat{\jmath} + 4\hat{k}) = 18$ J

(18) Why wheels are made circular in automobiles? Why do we say friction is independent of area of contact?
Ans: It is easier to roll than slide because $\mu_r < \mu_k$.
Any change in area, leads to only variation in pressure experienced, but force to be balanced remains same.

GROUP – D

Answer the following questions (Alternatives are to be noted): [5 x 3 = 15]

(19) A particle acted on by two constant forces $4\hat{\imath} + \hat{\jmath} - 3\hat{k}$ and $3\hat{\imath} + \hat{\jmath} - \hat{k}$ and is displaced from the point $\hat{\imath} + 2\hat{\jmath} + 3\hat{k}$ to the point $5\hat{\imath} + 4\hat{\jmath} + \hat{k}$. Find the total work done by the forces.
Ans: Resultant of forces $\vec{F} = (4\hat{\imath} + \hat{\jmath} - 3\hat{k}) + (3\hat{\imath} + \hat{\jmath} - \hat{k}) = 7\hat{\imath} + 2\hat{\jmath} - 4\hat{k}$
Displacement $\overrightarrow{d} = (5\hat{\imath} + 4\hat{\jmath} + \hat{k}) - (9\hat{\imath} + 2\hat{\jmath} + 3\hat{k}) = 4\hat{\imath} + 2\hat{\jmath} - 2\hat{k}$
Work done = $\vec{F} \cdot \overrightarrow{d} = (7\hat{\imath} + 2\hat{\jmath} - 4\hat{k}) \cdot (4\hat{\imath} + 2\hat{\jmath} - 2\hat{k})$ = 40 units

(20) (a) Prove that 'the force will be minimum if it makes an angle with the inclined plane equal to the angle of friction'.
Ans: When the body is on the point of moving up the inclined plane, the force of limiting friction acts downward along the plane.
F cos λ = W sin θ + f_s = W sin θ + μ_sN or, W sin θ = F cos λ - μ_sN
W cos θ = F sin λ + N or, μ_s W cos θ = μ_s F sin λ + μ_sN
Adding both the equations we get, W (sin θ + μ_s cos θ) = F (cos λ + μ_s sin λ)
F = W (sin θ + μ_s cos θ)/ (cos λ + μ_s sin λ) = W sin $(\theta + \alpha)$/cos $(\lambda - \alpha)$
Where W, θ and α are constants for a given body and for a particular inclined planed at the particular place. So for F to be minimum, cos $(\lambda - \alpha)$ should be maximum. Or, cos $(\lambda - \alpha)$ = 1 or, $(\lambda - \alpha)$ = 0 or, $\lambda = \alpha$
Thus, the force will be minimum if it makes an angle with the inclined plane equal to the angle of friction
(b) Which will be exert more pressure, 100 kg mass on 10 m^2 or 50 kg mass on 4 m^2? Give reason.
Ans: Pressure = force/area, and where g is the acceleration due to gravity
First case: pressure = 10 x g /10 = 10g Pa and Second case: pressure = 50 x g / 4 = 12.5g Pa
Thus the pressure for the second case is more.

OR

(a) What is the angular acceleration of a particle moving in a circle of radius r with a angular speed ω?
Ans: Since angular speed ω is constant so angular acceleration is zero

(b) At what point of projectile path the speed is minimum? At what point the speed is maximum?
Ans: The speed is minimum at the highest point and at the projection point. (have to show the calculation)

(21) A proton and electron have kinetic energy equal to 10^5 eV and 10^4 eV respectively. Which of them moves faster? Also calculate the ratio of their speeds. Given mass of electron = 9.11 x 10^{-31} kg, mass of proton = 1.67 x 10^{-27} kg and 1 eV = 1.6 x 10^{-19} J
Ans: The electron moves faster. The ratio of their speeds = 1 : 13.57