FEDERAL UNIVERSITY OF AGRICULTURE, ABEOKUTA

DEPARTMENT OF MATHEMATICS

2018/2019 Second Semester Examination .

MTS 104: Mechanics

Time Allowed : 2 Hours.

Instruction: Answer any 4 Questions.

1(a). Aparticle is projected with a speed u and at an angle of elevation α from a point O. Show that at time t after projection, the position vector of the particle relative to O is r, where $r = (ucos\alpha)ti + [(usin\alpha)t - \frac{1}{2}gt^2]j$, i and j are unit vector directed horizontal and vertically upwards respectively.

(b). Given that $u = 40ms^{-1}$ and that the particle strikes a target A on the same horizontal level as O, where $OA = 60m$. Find the least possible time, to the nearest tenth of a second that elapses before the particle hits the target. $(g = 10ms^{-2})$.

(c). A running man has 3/4 the kinetic energy of that of a body whose mass is one-third of the man. The man speed up by $5m/s$ so as to have the same kinetic energy as that of the body. Find the original speed of the man.

2(a). A particle is projeected up a plane with an initial speed of $50m/s$ from a point O in a plane inclined 45^0 to the horizontal. The plane containing the path passes through the line of greatest slope of the inclined plane. Find (i) the maximum range of the particle (ii) the time of flight of the maximum range.

(b). A simple pendulum making small oscillation is released from a position where it makes an angle α with the vertical. Show that the complete period is $\frac{2\pi v}{g\alpha}$ wher v is the maximum speed.

3(a). A tripod consists of three light rigid legs AL, BL and CL which are freely pinned at their base points A,B,C and at their apex L. The position vectors of the points A,B,C and L with respect to some origin are $2i - j - 3k$, $3i + 2j + 2k$, $j + k$ and $2i + j + 3k$ respectively, where k points vertically upward. The tripod supports a camera of weight $2N$ at L. Calculate the magnitude of the resultant forces on the legs of the tripod.

(b). A body of mass $50kg$ is projected up an inclined plane of 47^0 with an initial speed of $5m/s$. The coefficient of the friction is 0.25. Calculate (i) How far up the slope it travels before coming to rest (ii) How long it takes to reach the highest point (iii) How much longer it takes to return to its starting point (iv) How fast its traveling when it gets there.

4(a). A spacecraft at a distance $r_0 = 2R_E$ from the center of the earth is moving outwards with initial velocity $v_0\sqrt{2gR_E/3}$. Determine its velocity as a function of its distance from the centre of the earth.

(b). A rocket booster is traveling straight up when it suddenly starts rotating counter clockwise at $0.25rev/s$. The range safety officer destroys it $2s$ later. The booster mass is $m = 90Mg$, its thrust is $T = 1.0MN$ and it is moving upwards at $10m/s$ when it starts rotating. If aerodynamic forces are neglected. What is the booster's velocity at the time it is destroyed?

5(a). The Apollo CSM(A) attempts to dock with the sayus capsule (B). Their masses are $m_a = 18Mg$ and $m_b = 6.6Mg$. The sayus is stationary relative to reference frame and the CSM approaches with velocity $v_a = (0.2i + 0.03j - 0.02k)m/s$. (i) If the first attempts at docking is succesful, what is the velocity of the center of mass of the combined vehicles afterwards? (ii). If the attempt is successful and the coefficient of the restitution of the resulting impact is $e = 0.95$, what are the velocities of the spacecraft after the impact?

6(a). When an earth satelite is at perigee, the magnitude of its velocity is $v_a = 700m/s$ and its distance from the center of the earth is $r_a = 10000km$. What are the magnitude of its velocity v_b and its distance r_b from the earth at apogee. The radius of the earth is $R_E = 6370km$.

(b). Two bodies having masses of $6kg$ and $15kg$ and traveling along the same straight line level path have respectively velocities of $12m/s$ right to left and $6m/s$ left to right, when they collide. The coefficient of restriction is $e = -0.85$. Calculate the two final velocities and the energy loss due to the collision.

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FEDERAL UNIVERSITY OF AGRICULTURE, ABEOKUTA

DEPARTMENT OF MATHEMATICS

2017/2018 BSc. DEGREE SECOND SEMESTER EXAMINATIONS

COURSE: MTS 104 (MECHANICS)

TIME ALLOWED: 2 HOURS , 30 MINUTES

INSTRUCTION : ANSWER ANY FOUR (4) QUESTIONS

(a) $ABCDEF$ is a regular hexagon and O is its centre. Forces $1, 2, 3, 4, P$ and Q Newtons act on O in the direction OA, OB, OC, OD and OF respectively. If the six forces are in equilibrium, find the values of P and Q. −1 3 5

(b) One end of a string $0.5m$ long is fixed to point A and the other end is fastened to a small object of weight $8N$. The object is pulled aside by a horizontal force until it is $0.3m$ from the vertical through A. Find the magnitude of the tension in the string and the horizontal force. T = W

a) Distinguish between the following pairs:

(i) A resultant force and an equilibrant force

(ii) Torgue and Work

b) A uniform plank AB of weight $100N$ and length $4m$ lies on a horizontal roof perpendicular to the edge of the roof and overhanging by $1.5m$. If a load of $200N$ is to be attached to the overhanging end A, what force must be applied to the opposite end B just to prevent the plank from overturning?

(c) Let P and Q be given forces acting on points A and B respectively. With the aid of a suitable diagram each, find the magnitude of the resultant forces when

(i) P and Q are like parallel forces

(ii) P and Q are unlike parallel forces.

(a) Define Simple Harmonic Motion.

(b) One end A of a light elastic string of natural length l and Young's modulus of elasticity λ is fixed. To the other end is attached a particle of mass m and the assembly hangs freely under gravity. The particle is pulled down a further distance p and released.

(i) Show that initially, the motion of the particle is simple harmonic.

(ii) Determine its centre of oscillation.

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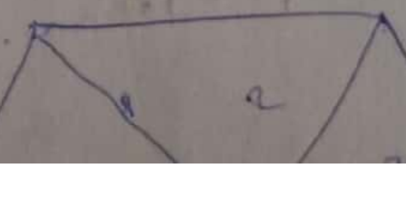


(a) A projectile is fired from the edge of a 300m cliff with an initial velocity of 300m/s at an angle of 30 degrees with the horizontal. Neglecting air resistance, find

(i) the horizontal distance from the gun to the point where the projectile strikes the ground

(ii) the greatest elevation above the ground reached by the projectile

(b) Define the following:

(i) Coplanar forces

(ii) Concurrent forces

(a) Let F be a constant force which acts on a body such that it makes an angle θ with the horizontal. Let the body be displaced through a distance s.

(i) Represent the above graphically

(ii) Resolve F componentwise

(iii) What is the work done by the force in displacing the body through distance s?

(iv) What is the work done if a force $F = (6i + 4j)N$ is applied over a particle which displaces it from its origin to the point $R = (3i - 2j)$ metres? 10

(b) State and prove the energy-work Theorem

(c) (i) A spring of spring constant $(4 \times 10^3)N/m$ is stretched initially by 4cm from the unstretched position. What is the work required to stretched it further by another 4cm? 9.6 Nm

(ii) Define power? Hence calculate the instantaneous power applied to a particle that moves with velocity $V = (10i - 6j + 10k)ms^{-1}$ under the influence of a constant force $F = (20i - 20j + 20k)N$. 280 ms^{-1}

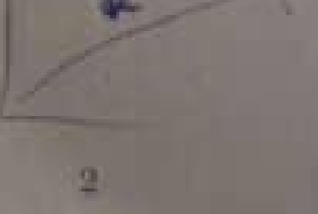
(a) A sail controller at a seaport observes two ships A and B simultaneously, their position vectors being $(10i + 20j + 5k)Km$ and $(-20j - 10j + 3k)Km$ respectively relative to the tower. Ship A is sailing with a constant velocity of $(-20i - 50j)Kmhr^{-1}$ and ship B is sailing with a constant velocity of $(150i + 250j + 60k)Kmhr^{-1}$. Find:

(i) The velocity of ship A relative to ship B $(-170i - 300j - 60k)$ $kmhr^{-1}$

(ii) The position vector of ship A relative to ship B at t minutes after the ships are observed. $((100 - 170t)i + (100 - 300t)j + (400 - 60t)k)$

(b) Forces P and Q inclined at an angle of 60 degrees act on a particle of mass $2.5Kg$. P has a magnitude of $5N$ and Q has a magnitude of $8N$. Find the acceleration of the particle. 4.54 ms^{-2}

$W = F \cos\theta\, s$



Car comes to a downhill stretch inclined at 2^0 to the horizontal. What is its maximum speed downhill, if the power and resistance remain unchanged ?

(b) The combined mass of a Cyclist and her bicycle is 65kg. She accelerated from rest to $8m/s$ in 80m along a horizontal road. (i) Calculate the work done by the net force in accelerating the cyclist and her bicycle (ii) Calculate the net forward force.

(c) A bullet of $25kg$ is fixed at a wooden barrier 3cm thick. When it hits the barrier it is traveling at $200m/s$. The barrier exerts a constant resistive force of $5000N$ on the bullet. (i) Does the bullet pass through the barrier and if so with what speed does it emerge, is energy conserved in this situation ?

SECTION B

4(ai) Define the term Simple Harmonic motion

(ii) With the aid of a diagram, considering the motion of a block of mass M attached to one end of a spring, the other of which is fixed , derive the equation for Simple harmonic motion

(iii) What is the name given to any system that obeys an equation of the form derived in (ii) above

(b) At time $t = 0$, the position of the mass of a harmonic oscillator is observed to be $x(0)$ and ist velocity is $v(0)$. From the the equation below, Determine the displacement and celocity at the given time and evaluate the complete solution

$$x = X_0 \cos(w_0 t + \phi)$$

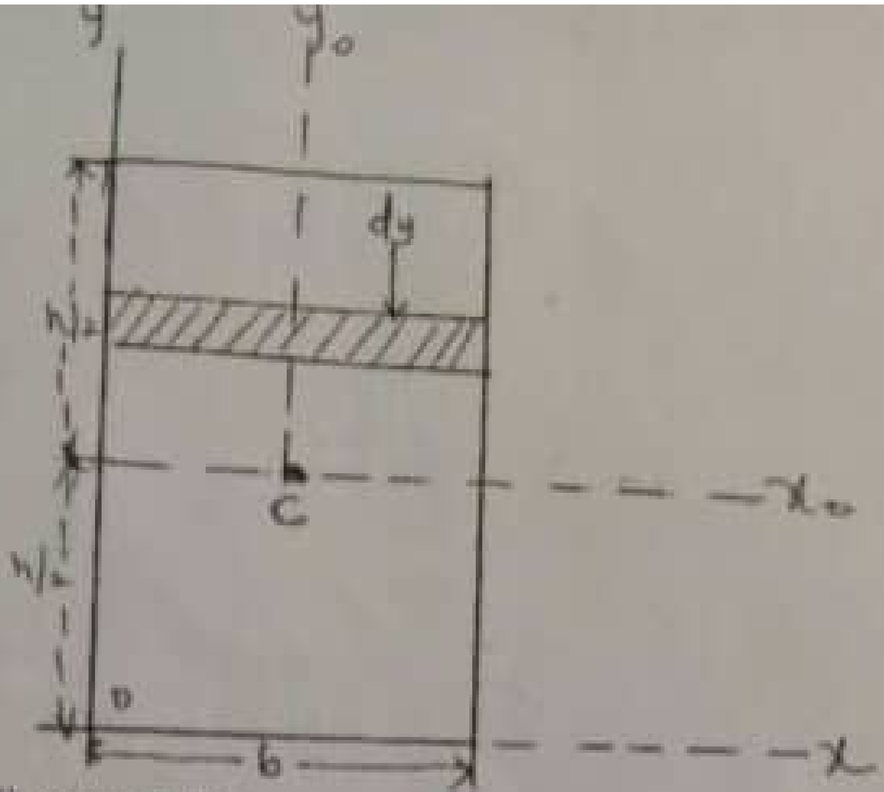
where the (quantity $w_0 t + \phi$ is the plane of the oscillation at time t and ϕ is the plane constant)

5(a) Write short note on the following

(i) Moment of Inertia (ii) Centroid (iii) Perpendicular Axis Theorem (iv) Parallel Axis Theorem

(b) In the Diagram below, determine the moments of inertia of the rectangular area about the centroidal x_0 and y_0 axes, the centroidal polar axis z_0 through C, the x-axis and the polar axis z through O

$V = U \cos \theta$

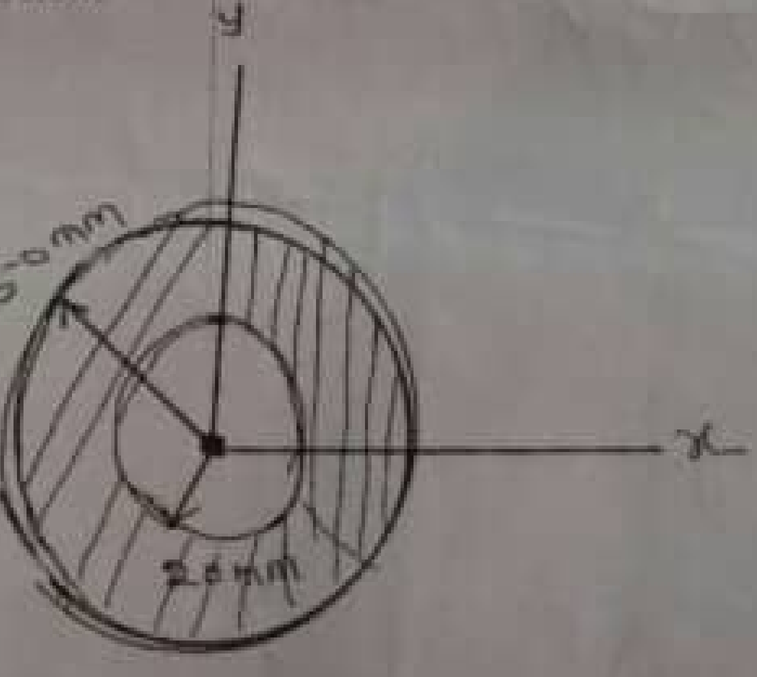


6(a) Define the following terms

(i) Momentum (ii) Impulse (iii) Coefficient of restitution

(b) A particle of mass m impacts a smooth wall at $4um/s$ at angle of 30^0 to the vertical. The particle rebounds with a speed ku at 90^0 to the original direction and in the same plane as the impact trajectory. What is (i) the value of the constant K? (ii) the coefficient of restitution between the wall and the particle? (iii) the magnitude of the impulse of the wall on the particle

(c) Determine the moment of inertia of the Cross hatched region about the x-axis in the diagram below.

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STUDENT'S UNION GOVERNMENT
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