(Knowledge for Development)

KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS

2020/2021 ACADEMIC YEAR

END OF SEMESTER EXAMINATIONS

THIRD YEAR SECOND SEMESTER

MAIN EXAMINATION

FOR THE DEGREE OF BACHELOR OF SCIENCE

MATHEMATICS

COURSE CODE: **MAA 324**

COURSE TITLE: **DYANAMICS 2**

DATE: **4/10/2021** **TIME: 2:00 PM – 4:00 PM**

INSTRUCTIONS

Answer **Questions ONE a**nd Any other **TWO**

QUESTION ONE [30MKS]

a. A particle moves so that its position as a function of time is $\vec{r} = \hat{i} + 4t^2\hat{j} + t\hat{k}$, write the expression for (3mks)

i. Its velocity

ii. Acceleration as a function of time

b. A track is traveling south at a speed of 70km/h toward an intersection. A car is traveling east towards the intersection at a speed of 80km/h. what is the velocity of the car relative to the truck? (5mks)

c. Two particles of masses m1=1kg and m2=2kg have position vectors given by $\vec{r}_1 = (2t\hat{i} - 4\hat{j})m$ and $\vec{r}_2 = (5t\hat{i} - 2t\hat{j})m$ respectively where t is time. Determine the velocity and linear momentum of the center of mass of the two-particle system at any time and at t=1s (4mks)

d. A car drives north at 25m/s for 60s, then turns east and drives at 30m/s for 120s. What is the magnitude and direction of the average velocity for the trip? (5mks)

e. A rocket moves with speed v_{rel} = 0.866 (so γ = 2) along the x-direction in the laboratory. In the rocket frame an event occurs at coordinates x' =10m, y' = 7 meters, z' = 3 meters, and t' = 20 seconds of light-travel time with respect to the reference event. What are the coordinates of the event as observed in the laboratory? (5mks)

f. Determine the virtual work δW done by the force $\vec{F} = 4\hat{i} + 3\hat{j}$ where i and j are the unit vectors in the x and y directions over a virtual displacement δq with the constants $x = r\cos\theta$, $y = r\,sin\theta$. Use the generalized coordinates $q_1 = r$ and $q_2 = \theta$ (4mks)

g. A stationery person observes that rain is falling vertically down at 30km/h. a cyclist is moving on the level road at 10km/h. in which direction should the cyclist hold his umbrella to protect himself from rain? (4mks)

QUESTION TWO [20MKS]

a. A particle moving with initial velocity $\vec{v} = 50m/s\,j$ undergoes an acceleration $\vec{a} = [(35 + 2t^3)i + (4 - t^2)j]m/s^2$. what are the particles position and velocity after 3s assuming it starts at the origin (8mks)

b. A delighted math's graduate throws her cap into the air with an initial velocity of 24.5m/s at 36.9^0 above the horizontal. The cap is later caught by another student. Find (6mks)

i. The total time the cap is in the air

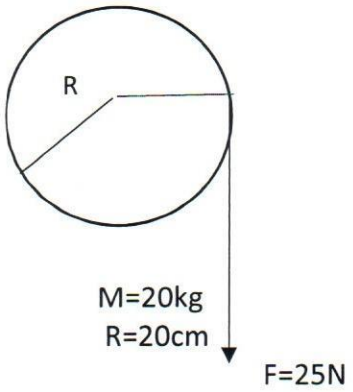
ii. The total horizontal distance travelled (ignore air resistance)

c. The angular speed of a motor wheel is increased from 1200rpm to 3120rpm in 16 s. determine the angular acceleration and number of revolutions the engine makes during this time. (6mks)

QUESTION THREE [20MKS]

a. A surveyor measures a street L=100m long in earth frame S. use the Lorentz transformation to obtain an expression for its length as measured from spaceship S', moving by at speed 0.20c, assuming the x coordinates of the two frame coincide at t=0. (6mks)

b. A cord of negligible mass is wound round the rim of a fly wheel of mass 20 kg and radius 20 cm. A steady pull of 25 N is applied on the cord as shown. The flywheel is mounted on horizontal axle with frictionless bearings. (7mks)



i. Compute the angular acceleration of the wheel.
ii. Find the work done by the pull, when 2m of the cord is unwound.
iii. Find also the kinetic energy of the wheel at this point. Assume that the wheel starts from rest.

c. Suppose a ballistic missile is first due eastward at 43^0N latitude. If the missile travels 1000km at a speed of 500m/s, by how much is it deflected due to Coriolis force? (7mks)

QUESTION FOUR [20MKS]

a. Two particles of masses m_1=1kg and m_2=2kg are moving in the x-y plane. Their position vectors relative to the origin are $\vec{r}_1 = (t^2\hat{i} - 2t\,\hat{j})m$ and $\vec{r}_2 = (3t\hat{i} + \hat{j})m$ where t is time. Find (10mks)

i. the total angular momentum of the system, the total external torque acting on the system, total kinetic energy of the system all relative to the origin at any time
ii. Repeat (i) relative to center of mass

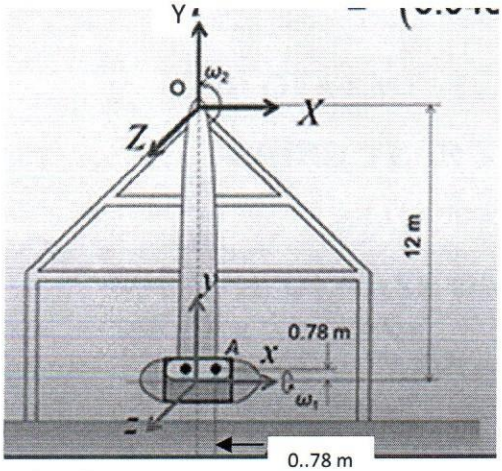
b. Consider a pendulum made of a spring with a mass m on the end. The spring is arranged to lie in a straight line (which we can arrange by, say, wrapping the spring around a rigid

massless rod). The equilibrium length of the spring is l. Let the spring have length $l+x(t)$ and let its angle with the vertical be θ(t). Assuming that the motion takes place in a vertical plane, find the equations of motion for x and θ. (5mks)

c. An airplane propeller is rotating with uniform angular speed of 1800rpm. The blades of the propeller are 6ft long. Determine the linear speed of a point 2ft from the axis and 6ft from the axis. (5mks)

QUESTION FIVE [20 MKS]

a. The figure below shows a ride in an amusement park. The main arm carries a cock pit to seat two occupants. The main arm rotates at an angular speed ω_2 relative to the ground. Determine the absolute velocity and acceleration at point A for the position shown if $\omega_1 = 2.4 rad/s$ and $\omega_2 = 0.24 rad/s$ (8mks)



b. In a particle accelerator, when electrons accelerated to 0.999c collide with a target, the collision produces a muon which moves in the direction of the electron with a speed of 0.95c. What is the muon's momentum in the lab frame and in the frame of the electron beam? (mass of muon $1.9\times10^{-28} kg$) (6mks)

c. A flywheel of diameter 2ft spins about the axis through its center and perpendicular to the plane of the wheel at 1000rpm. The wheel weighs 20lbf (pound-force).assuming the wheel to be a thin, uniform disk, find its kinetic energy. ($1lbf = 32.2lbm \times 1\,{}^{ft}/_{s^2}$) (6mks)