CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN PHYSICS

PHYS 333: MECHANICS II

STREAMS: PHYSICS Y3S1 **TIME: 2 HOURS**

DAY/DATE: THURSDAY 13/12/2018 **11.30 A.M – 1.30 P.M**

INSSTRUCTIONS:

Answer question ONEand any other TWO questions.

Use of mathematical tables and calculator is permissible

Use the following constants; $c = 3.0 \times 10^8$m/s
v = 343 m/s as the speed of soundwaves in air
$\rho = 1.20$ kg/m^{3}as the density of air
v = 1 493 m/s is speed of sound in water
v = 5 950 m/s is speed of sound in iron
$\rho = 7.86 \times 10^3$Kgm^{-3} is the density of iron

Question One.

a. State the three Newton laws of motion for rotary motion giving the mathematical equations for each of them. (6 marks)
b. Explain what is meant by i) time dilation, ii)length contraction giving the mathematical expressions for each of them.. (4 marks)
c. State and write the equation for the work-energy theorem for a body in rotary motion. (2 marks)
d. Differentiate between the total kinetic energy for a body in rotary motion and that in linear motion.. (2 marks)
e. Differentiate between the scalar and vector products giving the equation for each of them. Hence give a physical application of each of them. (6 marks)
f. A force of $\mathbf{F} = (2.00\hat{\mathbf{i}} + 3.00\hat{\mathbf{j}})$ N is applied to an objectthat is pivoted about a fixed axis aligned along the *z* coordinateaxis. If the force is applied at a point located at$\mathbf{r} = (4.00\hat{\mathbf{i}} + 5.00\hat{\mathbf{j}})$ m, find the torque vector $\boldsymbol{\tau}$. (3 marks)
g. Differentiate between i) infrasonic, ii) sonic and iii) ultrasonic frequencies. (3 marks)
h. What is Doppler effect? (2 marks)

i. What is Lorentz transformation? (2 marks)

Question two.

a. A wheel starts from rest and rotates with constant angular acceleration to reach an angular speed of 12.0 rad/s in 3.00 s. Find (i) the magnitude of the angular acceleration of the wheel and (ii) the angle in radians through which itrotates in this time. (6 marks)

b. A wheel 2.00 m in diameter lies in a vertical plane and rotateswith a constant angular acceleration of 4.00 rad/s^2.The wheel starts at rest at $t = 0$, and the radius vector of acertain point *P* on the rim makes an angle of 57.3° withthe horizontal at this time. At t =2.00 s, find (i) the angular speed of the wheel, (ii) the tangential speed and the totalacceleration of the point *P*, and (iii) the angular positionof the point *P*. (8 marks)

c. A projectile of mass *m* moves to the right with a speed *vi*as shown in the figure below. The projectile strikes and sticks to the endof a stationary rod of mass *M*, length *d*, pivoted about africtionless axle through its center (Fig.1b). (i) Findthe angular speed of the system right after the collision.(ii) Determine the fractional loss in mechanical energydue to the collision. (8 marks)

Question Three.

a. Two vectors are given by **A** = -3**i** + 7**j** - 4 **k** and**B** = 6**i** -10**j** + 9 **k**. Evaluate the quantities (i)$\cos^{-1}$[**A**.**B**/*AB*] and (ii) $\sin^{-1}$[|**A** x**B**|/*AB*]. (iii) Whichgive(s) the angle between the vectors? (6 marks)

b. A particle is located at the vector position **r** # (**i**+ 3**j**) m,and the force acting on it is **F** # (3**i** + 2**j**) N. What is the torque about (i) the origin and (ii) the point having coordinates(0, 6) m? (6 marks)

c. Two forces **F**1 and **F**2 act along the two sides of an equilateraltriangle as shown in Figure 2 below. Point *O* is the intersectionof the altitudes of the triangle. Find a third force **F**3 to beapplied at *B* and along *BC* that will make the total torquezero about the point *O*. **What If?** Will the total torquechange if **F**3 is applied not at *B* but at any other point along*BC*? (8 marks)

Question four.

a.Your clock radio awakens you with a steady and irritatingsound of frequency 600 Hz. One morning, it malfunctionsand cannot be turned off. In frustration, you drop the clockradio out of your fourth-story dorm window, 15.0 m fromthe ground. Assume the speed of sound is 343 m/s.**(i)** As you listen to the falling clock radio, what frequency doyou hear just before you hear the radio striking the ground?**(ii)** At what rate does the frequency that you hear changewith time just before you hear the radio striking the ground?

(8 marks)

b.Consider sinusoidal sound waves propagating in thesethree different media: air at 0°C, water, and iron. Use densitiesand speeds from Tables 1 and 2. Each wave hasthe same intensity I_0 and the same angular frequency ω_0.(i) Compare the values of the wavelength in the three media.(ii) Compare the values of the displacement amplitudein the three media. (iii) Compare the values of thepressure amplitude in the three media. (iv) For values ofω_0= 2 000 π rad/s and I_0 # 1.00 x 10^{-6} W/m^2, evaluatethe wavelength, displacement amplitude, and pressure amplitudein each of the three media. (12 marks)

Question five.

a. An astronomer on Earth observes a meteoroid in thesouthern sky approaching the Earth at a speed of 0.800*c*.At the time of its discovery the meteoroid is 20.0 ly from the Earth. Calculate (i) the time interval required for themeteoroid to reach the Earth as measured by the Earthbound astronomer, (ii) this time interval as measured by a tourist on the meteoroid, and (iii) the distance to the Earthas measured by the tourist. (6 marks)

b. A spacecraft is launched from the surface of the Earth with avelocity of 0.600*c* at an angle of 50.0° above the horizontalpositive *x* axis. Another spacecraft is moving past, with avelocity of 0.700*c* in the negative *x* direction. Determine themagnitude and direction of the velocity of the first spacecraftas measured by the pilot of the second spacecraft. (6 marks)

c. An astronaut wishes to visit the Andromeda galaxy, makinga one-way trip that will take 30.0 yr in the spacecraft'sframe of reference. Assume that the galaxy is 2.0 x 10^6lyaway and that the astronaut's speed is constant. (i) Howfast must he travel relative to the Earth? (ii) What will bethe kinetic energy of his 1 000-metric-ton spacecraft? (iii) What is the cost of this energy if it is purchased at atypical consumer price for electric energy: sh0.130/kWh? (8 marks)
