NATIONAL OPEN UNIVERSITY OF NIGERIA
PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA
FACULTY OF SCIENCES
DEPARTMENT OF PURE AND APPLIED SCIENCE

2021_1 EXAMINATIONS

COURSE CODE: **PHY 301**

COURSE TITLE: **CLASSICAL MECHANICS II**
CREDIT UNIT: **3**
TIME ALLOWED: **(2½ HRS)**

INSTRUCTION: ***Answer question 1 and any other four questions***

QUESTION 1

(a) State the three Kepler's laws and write the mathematical form of the laws. (6marks)

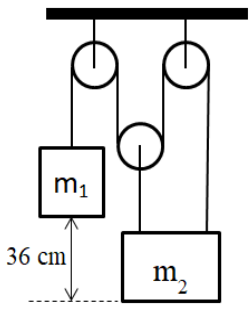
(b) Define Central Force and write mathematical expression for centre force. (4marks)

(c) Write the Lagrangian of the following systems,
i. Free particle
ii. Freely rotating wheel
iii. Point mass in gravitational field (6marks)

(d) Prove that the Hamiltonian of Harmonic Oscillator is given by
$H = \frac{p^2}{2m} + k\frac{x^2}{2}$ (6marks)

QUESTION 2

The heights of the two blocks in the diagram below differ by 36cm. When they are released from rest, the higher block falls while the lower block rises. One of the blocks has a mass that is three times the mass of the other block, the pulleys are massless and frictionless, and the string doesn't stretch.



a. Find the distance that the lower block rises when the two blocks are aligned. (6marks)

b. Find the time it takes for the two blocks to be aligned. (6marks)

QUESTION 3

Consider a simple plane pendulum consisting of a mass m attached to a string of length *l*. After the pendulum is set in motion, the length of the string is shortened at a constant rate

$$\frac{dl}{dt} = -\alpha = constant$$

The suspension point remains fixed.

(a) Compute the Lagrangian function and find the equation of motion (6marks)

(b) Write the energy function (h) of the system (4marks)

(c) Is the energy function h an integral of motion? Is the energy conserved? Explain your results.

(2marks)

QUESTION 4

(a). The mass of Earth is 5.97×10^{24} kg, the mass of the Moon is 7.35×10^{22} kg, and the mean distance of the Moon from the centre of Earth is 3.84×10^{5} km. Use these data to calculate the magnitude of the gravitational force exerted by Earth on the Moon. (6marks)

(b) The planet Venus orbits the Sun with a mean orbital radius of 1.076×10^{11} m. The mass of the Sun is 1.99×10^{30} kg. Using Newton's version of Kepler's third law, calculate the orbital period of Venus. (6marks)

QUESTION 5

(a). Write down the Lagrangian for a simple harmonic oscillator and obtain the expression for the time period. (6marks)

(b). A particle of mass m slides on a smooth incline at an angle α. The incline is not permitted to move. Determine the acceleration of the block. (6marks)

QUESTION 6

Consider a particle of mass m moving in a plane under the attractive force $\mu m/r^2$ directed to the origin of polar coordinates (r, θ). Determine the equations of motion. (12marks)