KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER
SPECIAL/SUPPLEMENTARYEXAMINATIONS

FOR THE DEGREE OF B.ED (SCIENCE) AND BSC (PHYSICS)

COURSE CODE: SPH 312

COURSE TITLE: CLASSICAL MECHANICS II

DURATION: 2 Hours

DATE: 11/1/2022 **TIME:** 2-4PM

INSTRUCTIONS TO CANDIDATES

- Answer question one (**Compulsory**) and any other **Two** questions.
- Attempted questions must be indicated on front cover of answer booklet.
- Every question should be started on new page and question indicated respectively.

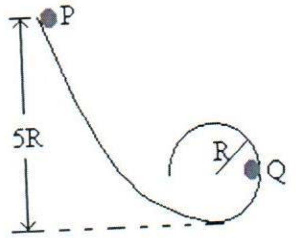
Question One (30 Marks)

a. Discuss the relativistic principle according to the Newtonian mechanics (2mks)

b. State the Hamiltonian principle. (2mks)

c. Discuss the difference between kinematics and dynamics as used in study of motion and state the limitation of classical mechanics. (3mks)

d. A small block of mass m slides along the frictionless loop track shown in the figure below.



i. If it starts from rest at P, what is the resultant force on it at Q? (3mks)

ii. At what height above the bottom of the loop should the block be released so that the force exerted on it by the track at the top of the loop is equal to its weight? (3mks)

e. Discuss Holonomic Constraints and non-holonomic Constraints giving an example in each case. (4mks)

f. State the Kepler's Law of Periods that explain the motion of planets. (2mks)

g. Distinguish between inertia mass and gravitational mass of an accelerated object. (3mks)

h. In a radioactive decay, an alpha particle, which is the nucleus of the He-atom, is emitted from a Uranium-238 nucleus originally at rest, with a speed of $1.4 \times 10^7 ms^{-1}$ and a kinetic energy of 4.1MeV. Find the recoil speed of the residual nucleus which is Thorium-234. (4mks)

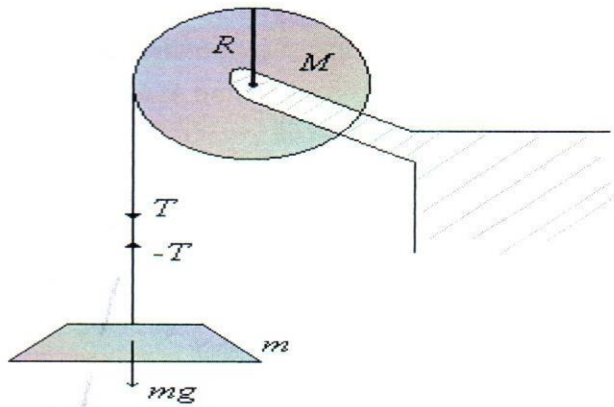
i. A rocket is moving away from the solar system at a speed of $6.0 \times 10^3 ms^{-1}$. It fires its engine which ejects exhaust with a relative velocity of $3.0 \times 10^3 ms^{-1}$. The mass of the rocket at this time is $4.0 \times 10^4 kg$ and it experiences an acceleration of $2.0 ms^{-2}$. Fin

   i. The velocity of the exhaust relative to the solar system. (3mks)

   ii. The rate at which the exhaust was ejected during the firing. (3mks)

Question Two (20 Marks)

a. A uniform disc of radius R and mass M is mounted on an axle supported in fixed frictionless bearings as shown in the figure below. A light cord is wrapped around the rim of the wheel. A body of mass m hangs from the other end of the cord. Find the angular acceleration of the disc and tangential acceleration of a point on the rim of the disc. Find also the tension in the cord. (8 marks)



b. Consider a circular disc of mass M and radius R rolling down an inclined plane without slipping. Find the speed of its center of mass when it reaches the bottom of the incline. (6 marks)

c. Prove that the magnitude R of the position vector for the center of mass from an arbitrary origin is given by the equation

$$M^2R^2 = M\sum_i m_i r_i^2 - \frac{1}{2}\sum_{ij} m_i m_j r_{ij}^2 \qquad \text{(6 marks)}$$

Question Three (20 Marks)

a. Use Hamilton's Principle to find the equation of motion of a one-dimensional harmonic oscillator. (8 Marks)

b. An object is projected vertically upward from the earth's surface with initial speed v_o. Neglecting air resistance, show that the speed of the object at a distance H above the earth's surface is

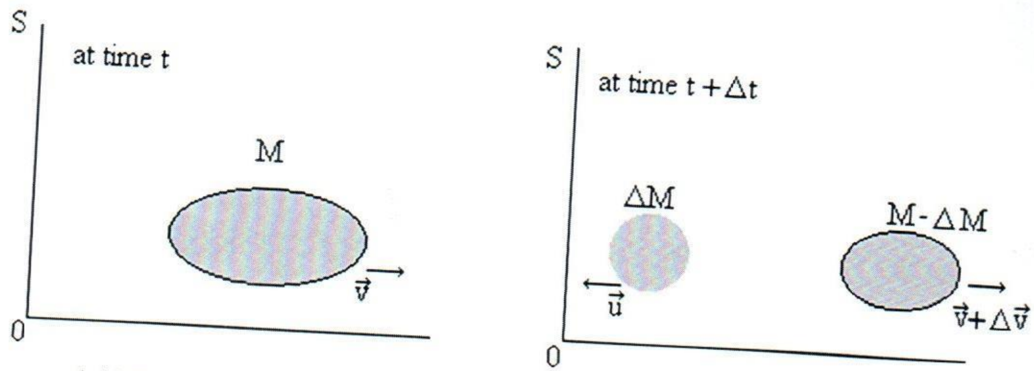
$$v = \sqrt{{v_o}^2 - \frac{2GMH}{R(R+H)}} \qquad \text{(6 Marks)}$$

c. The position vector of a particle v and its velocity relative to the centre of mass are $\vec{r}_v'$ and $\vec{v}_v'$ respectively. Prove that

(i) $\sum_v m_v \vec{r}_v' = 0$ and (ii) $\sum_v m_v \vec{v}_v' = 0$ (6 mark)

Question four (20 Marks)

a. Given that the initial mass of the rocket and the fuel it contains as M and its center of mass velocity as seen from some frame of reference S after time Δt as $\vec{v}$, as shown in fig.(a).



initial condition

(a)

final condition

(b)

After change in time Δt, the mass ΔM has been ejected in the form of gases generated within the rocket as that much amount of fuel has been burnt during this time. Letting $\vec{u}$ be the velocity of the center of mass of the ejected gas and $\vec{v}+\Delta\vec{v}$ be velocity of the center of mass of the rocket and the remaining fuel system as observed from the given frame of reference as shown in fig. (b). Show that Newton second law of motion of variable mass is given by

$$\vec{F}_{ext} = \frac{d}{dt}(M\vec{v}) - \vec{u}\frac{dM}{dt}$$

(8Marks)

b. Show that for a single particle with constant mass the equation of motion implies the following differential equation for the kinetic energy: $\frac{dT}{dt} = F.v$ while if the mass varies with time the corresponding equation is $\frac{d(mT)}{dt} = F.p$ (6marks)

c. Given that the mass m is attached to a spring of force constant k obtain its equation of motion and frequency of oscillation using Lagrange equations. (6marks)