KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2017/2018 ACADEMIC YEAR

SECOND YEAR FIRSTSEMESTER
MAIN EXAMINATIONS

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

COURSE CODE: SPH 212

COURSE TITLE: CLASSICAL MECHANICS I

DURATION: 2 HOURS

DATE: 19TH JANUARY 2018 TIME: 2 – 5PM

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- Indicate **answered questions** on the front cover.
- Start every question on a new page and make sure question's number is written on each page.

This paper consists of **4** printed pages. Please Turn Over

Question One (30 Marks)

(a) i. What is dimensional analysis (1mk)

ii. State one function of dimensional analysis (1mk)

(b) Given that a vector of magnitude **v** makes an angle θ with X axis.

i. Resolve the components υ_x and υ_y (1mk)

ii. Find its magnitude and direction using the resolved components. (2mks)

(c) An object suspended by a coil spring oscillates up and down so that the displacement from its equilibrium position varies with time according to $x = A\ Sin\omega t$ where A is maximum displacement of the object on either side of the equilibrium position. Find the acceleration of this object. (2mks)

(d) What are conservative forces? (1mk)

(e) Given two masses m_1 and m_2 of each 5Kg joined by a rigid rod. Find the moment of inertia about the normal through one mass. (5mks)

(f) i. Show that rotational power is given as $P=T\omega$, where symbols have their usual meaning. (1mk)

ii. An automobile uses 100watts and moves at a uniform speed of 72km/hr. What is the forward thrust exerted by the engine on the car? (2mks)

(g)i. What is a state variable? (1mk)

ii. At the beginning of a reversible expansion, according to a linear law, the fluid behind a piston exerts a force of 8KN on the piston. The expansion causes the volume to increase from $0.005m^3$ to $0.2m^3$. If the effective cross-sectional area and final pressure are $0.008m^2$ and $200KN/m^2$ respectively. Calculate the work done on the fluid. (3mks)

(i) i. State and discuss third law of thermodynamics. (3mks)

ii. What is a thermodynamic process? Give two examples of thermodynamic processes. (3mks)

j) 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 (4mks)

Question Two (20Marks)

(a) State and prove the theory of parallel axis(8mks)

(b) i. Name and state Kepler's three laws of planetary motion (3mks)

(c) State the three properties of central force fields (3 mks)

(d) State and prove the theory of perpendicular axis (6 mks)

Question Three (20 Marks)

(a) 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 $2.0 ms^{-2}$. Find

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)

(b). i. In an analysis of a rocket in motion, M is the initial mass of the rocket, υ is its centre of mass velocity and υ_o the velocity of the centre of mass of the ejected gas. Show that the external force F_{ext} is give by

$$F_{ext} = \frac{d}{dt}(M\vec{v}) - \vec{v}_o \frac{dM}{dt} \text{ (4mks)}$$

(c). Two skaters collide and embrace each other. One has mass m_1 = 70kg and is initially moving east at a speed u_1 = 6km/h while the other has mass m_2 = 50kg and is initially moving north at a speed u_2 = 8km/h.

i. What is the final velocity of the couple? (5mks)

ii. What fraction of the initial kinetic energy is lost because of the collision? (5mks)

Question Four (20 Marks)

(a). State any two conclusions that can be drawn from Archimedes' principle about density and floating. (2mks)

(b). State Stokes' law and show that the terminal velocity υ is given as

$$v = \frac{2}{9}\frac{r^2 g}{\eta}(\rho_s - \rho_f) \qquad \text{(5mks)}$$

where symbols have their usual meaning.

(c). Show that the position vector $\vec{R}_{CM}$ for the centre of mass is given by

$$\vec{R}_{CM} = \frac{1}{M}\int \vec{r}.dM$$

For bodies whose mass is continuously and evenly distributed. Where dM is the element of mass chosen at position $\vec{r}$ with respect to an origin in a Cartesian system. (7mks)

(d). The pressure difference between two points along a horizontal pipe, through which water is flowing, is 1.4 cm of mercury. If due to non-uniform cross-section, the speed of flow of water at the point of greater cross-section is 60cm/sec calculate the speed at the other part (6mks)

Question Five (20 Marks)

(a) State and prove the work energy theorem (10 mks)

(b) explain the nature of conservative forces by taking up the motion of a mass-point attached to a spring (10 mks)