JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE WITH IT

3RD YEAR 1ST SEMESTER 2016/2017 ACADEMIC YEAR

MAIN CAMPUS

COURSE CODE: SPH 313

COURSE TITLE: CLASSICAL MECHANICS

EXAM VENUE: PHY LAB **STREAM: (BSc.)**

DATE: 26/04/16 **EXAM SESSION: 2.00 – 4.00 pm**

TIME: 2 HOURS

Instructions:

1. **Answer question 1 (compulsory) and ANY other 2 questions.**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

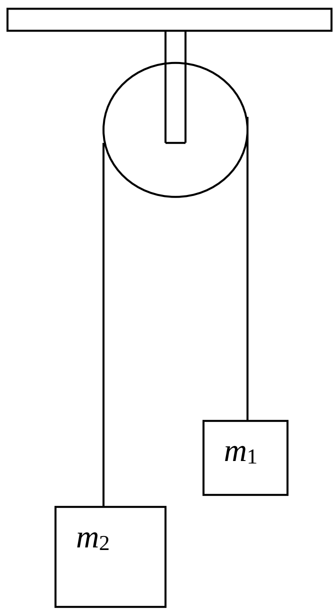
QUESTION ONE **(30 marks)**

a. From Newton's laws of motion, show that if the same force F acts on two particles with masses m_1 and m_2, then their accelerations a_1 and a_2 are related by

$$\frac{a_1}{a_2} = \frac{m_1}{m_2}$$

(3 marks)

b. The diagram below shows two masses m_1 and m_2 suspended over a pulley with an inelastic string. Given that m_1=50kg and m_2 = 30kg, find the tension on the string T and the common acceleration a of the two masses. (4 marks)



c. A block of mass m is held motionless on a frictionless plane of mass M and angle of inclination θ (see Fig. 2). The plane rests on a frictionless horizontal surface. The block is released. What is the horizontal acceleration of the plane? (6 marks)

d. Show that the escape velocity for a particle on a spherical planet of radius R and

mass$M$ under the Newtonian Gravitational constant G is given by the expression

$$v = \sqrt{\frac{2GM}{R}}$$ (4 marks)

e. Show that the total kinetic energy of a system in a laboratory frame is given my the sum of the kinetic energy of the centre of mass plus the kinetic energy relative to the centre of mass. i.e. $KE._{tot} = \frac{1}{2}mv_{cm}^2 + \frac{1}{2}\sum_i m_i v_i^2$. (4 marks)

f. Show that the shortest path between two fixed points in a plane is a straight line. (3 marks)

g. Obtain the Lagrangian of a mass suspended vertically on a spring. (3 marks)

h. Define the term relativity (1 mark)

i. State the postulates of general relativity (2 marks)

j. Briefly explain the concepts of time dilation and length contraction (4 marks)

QUESTION TWO

a. Mass M_1 is lying on a plane with inclination angle θ to the horizontal and mass M_2 hangs freely over the vertical side of the plane. See figure 2.1. The two masses are connected by a massless string which runs over a massless pulley. The coefficient of kinetic friction betweenM_1 and the plane is μ. M_1 is released from rest. Assuming that M_2 is sufficiently large so that M_1 gets pulled up the plane, show that the acceleration a of the masses and the tension T in the string are respectively given as;

$$a = \frac{g(M_2 - \mu M_1 \cos\theta - M_1 \sin\theta}{M_1 + M_2} \qquad T = \frac{M_1 M_2 g(1 + \mu\cos\theta + \sin\theta)}{M_1 + M_2}$$

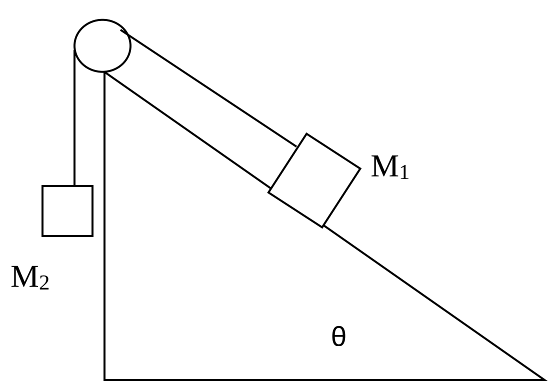


Figure 2.1

b. Obtain similar expressions for a and T when M1 is sufficiently larger than M2 such that M2 gets pulled up vertically as M1 slides down the plane. (10 marks)

QUESTION THREE

a. Derive The Euler–Lagrange equation of motion. (10 marks)

b. Consider a pendulum made of a spring with a mass m on the end (see Fig. 6.1). The spring is arranged to lie in a straight line. The equilibrium length of the spring is l. Let the spring have length $l+x(t)$ and let its angle with the vertical be $\theta(t)$. Assuming that the motion takes place in a vertical plane, find the equations of motion for x and θ.
(10 marks)

QUESTION FOUR

a. Clearly present the Galiliean transformations (6 marks)

b. Show that for a clock moving at a speed v, then the Lorentz factor γ is given by

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$ (9 marks)

c. Compute the value γ for a particle travelling at quarter the speed of light. (5 marks)

QUESTION FIVE

a. A clock starts on the ground and then moves up a tower at constant speed v. It sits on top of the tower for a time T and then descends at constant speed v. If the tower has height h, how long should the clock sit at the top so that it comes back showing the same time as a clock that remained on the ground? (10 marks)

b. A stick of length L moves past you at speed v. There is a time interval between the front end coinciding with you and the back end coinciding with you. What is this time interval in

i. your frame?

ii. the stick’s frame? (10 marks)