JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE)

3RD YEAR 1ST SEMESTER 2013/2014 ACADEMIC YEAR

REGULAR

COURSE CODE: SPH 313

COURSE TITLE: CLASSICAL MECHANICS

EXAM VENUE:LAB 6 **STREAM: (BSc. Science)**

DATE: 12/8/14 **EXAM SESSION: 2.00 – 4.00PM**

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.**

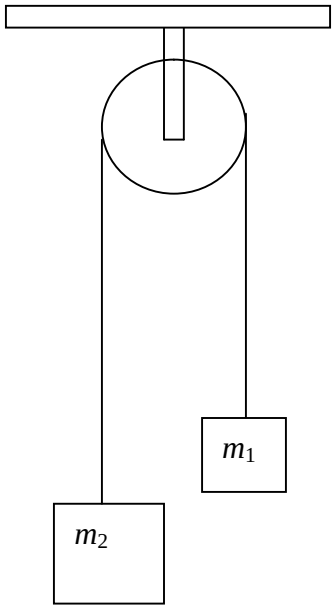
Answer question ONE and any other TWO questions

QUESTION ONE

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. Define the term escape velocity and show that the value for the escape velocity from the Earth's surface is 1.1×10^4m/s (4 marks)

d. Distinguish between conservative and non conservative forces (2 marks)

e. Show that the shortest path between two fixed points in a plane is a straight line.

(3 marks)

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

g. Define the term relativity (1 mark)

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

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

j. A plane flies at constant height *h*. What should its speed be so that an observer on the ground sees the plane's clock tick at the same rate as a ground clock? (3 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;

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

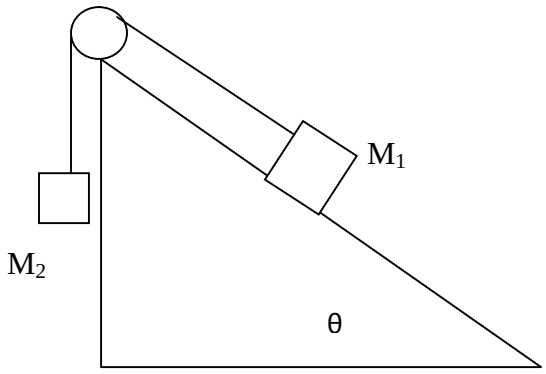
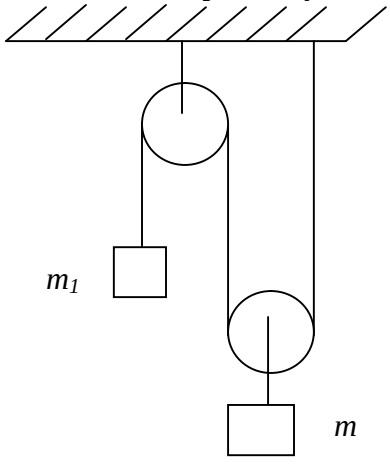


Figure 2.1

b. Consider the Atwood's Machine shown in figure 2.2 with masses m_1 and m_2. strings and pulleys are massless. Given that m_1=45kg and m_2=60kg, determine the accelerations a_1 and a_2 of the masses m_1 and m_2 respectively and the tension T in the string.



QUESTION THREE

a. 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 *θ(t)*. Assuming that the motion takes place in a vertical plane, find the equations of motion for *x* and *θ*. (10 marks)

b. A mass *m* is free to slide on a frictionless table and is connected, via a string that passes through a hole in the table, to a mass *M* that hangs vertically below the table. Assume that *M* moves in a vertical line only, and that the string always remains taut.

(i) Find the equations of motion for the variables *r* and *θ*. (4 marks)
(ii) Under what condition does *m* undergo circular motion? (2 marks)
(iii) What is the frequency of small oscillations (in the variable *r*) about this circular motion? (4 marks)

QUESTION FOUR

a. Define Lorentz factor (2 marks)

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

$$¥ = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$ (6 marks)

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

d. How fast must an object be moving if its corresponding value γ is to be 1.0 percent larger than γ when the object is at rest. (7 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 spaceship travels at speed *v* to a distant star. Upon reaching the star, it decelerates and then accelerates back up to speed *v* in the opposite direction (uniformly, and in a short time compared with the total journey time). By what fraction does the traveler age less than her twin on the earth? (Ignore the gravity from the earth.)
Work in:

(a) The earth frame. (5 marks)
(b) The spaceship frame. (5 marks)