JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

UNIVERSITY EXAMINATIONS

END SEMESTER EXAMINATIONS

BECHELOR OF EDUCATION SCIENCE

YEAR 3 SEMESTER 1 AUGUST 2013

SPH 313: CLASSICAL MECHANICS

(REGULAR PROGRAMME)

TIME 2 HRS

This paper consists of FIVE Questions. Answer QUESTION ONE(COMPULSORY) and any other TWO Questions.

QUESTION ONE (30 Marks)

a. Show that equation of motion for the kinetic energy for a single particle with constant mass is given by the differential equation

$$\frac{dT}{dt} = F.v$$

While if the mass varies with time then the corresponding equation is given by

$$\frac{d(mT)}{dt} = F.p$$

(4 marks)

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

(5 marks)

$$M^2R^2 = M\sum_i m_i r_i^2 - \frac{1}{2}\sum_{i,j} m_i m_j r_{ij}^2$$

c. Consider the pulley system in figure 1 with masses $\boldsymbol{M_1}$ **=4kg** and $\boldsymbol{M_2}$**=10kg.** The strings and pulleys are massless. Determine the common acceleration of the masses and the tension in the string? (5 marks)

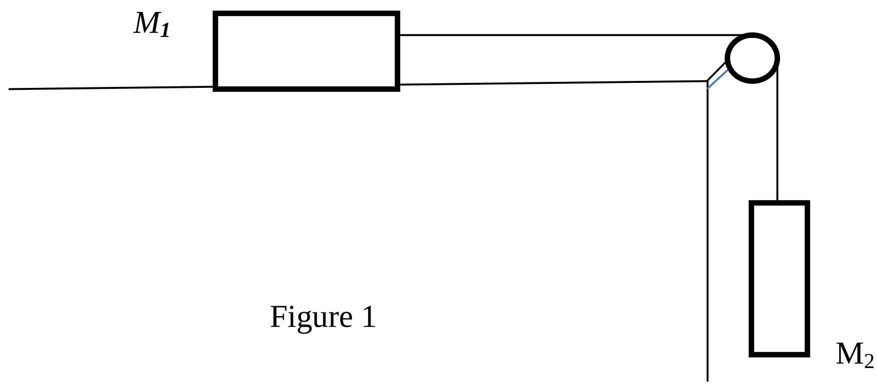

Figure 1

d. A mass hangs from a massless string of length, l. Conditions have been set up so that the mass is constrained to swing around in a horizontal circle, with the string making a constant angle β with the vertical. The system forms a conical pendulum. Determine the angular frequency, ω, of this motion. (5 marks)

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e. The escape velocity of a particle on Earth is the minimum velocity required at Earth's surface in order that that particle can escape from Earth's gravitational field. Neglecting the resistance of the atmosphere, the system is conservative. From the conservation theorem for potential plus kinetic energy show that the escape velocity for Earth, ignoring the presence of the Moon, is 11.2 km/s. (4marks)

f. Define a reference frame hence explain the term inertial reference frame (3 marks)

g. Briefly explain the concept of time dilation and length contraction with reference to special theory of relativity (4 marks)

QUESTION TWO (20 Marks)

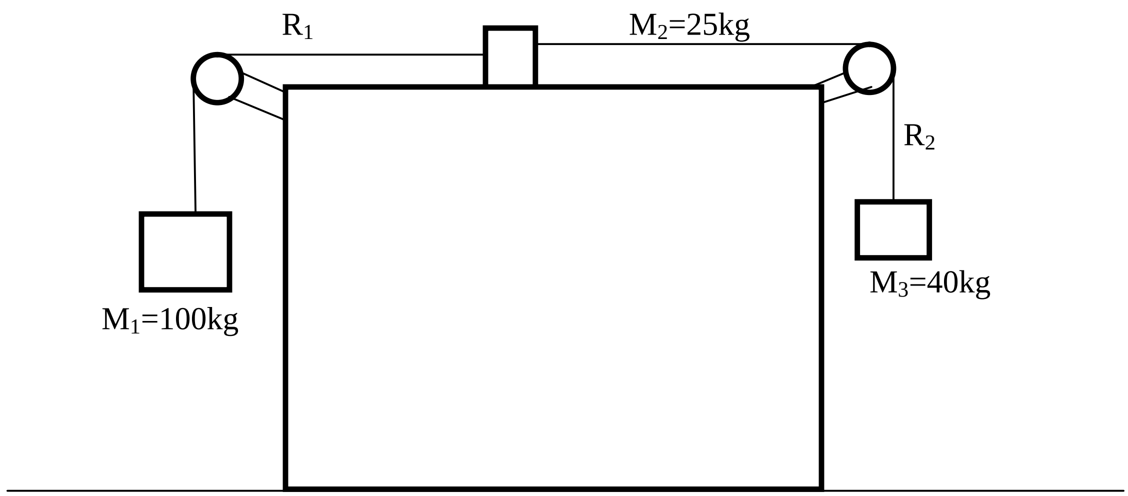
a. Mass M_1 is held on a plane with inclination angle θ to the horizontal, and mass M_2 hangs freely vertically over the side. The two masses are connected by a massless string which runs over a massless pulley. The coefficient of kinetic friction between M_1 and the plane is μ. M_2 is released from rest.

Assuming that M_2 is sufficiently large so that M_1 gets pulled up the plane, Determine

i) The common acceleration of the masses (7 marks)

ii) The tension in the string (6 marks)

b. Three blocks with masses M_1=100kg, M_2=25 kg and M_3= 40kg are connected with two ropes R_1 and R_2 over a solid platform as shown in the figure below. The horizontal surface and the pulleys are frictionless



Determine

i) the common acceleration of the blocks (3 marks)

ii) The tensions in the ropes R_1 and R_2. (4 marks)

QUESTION THREE (20 Marks)

a. Consider a uniform thin disk that rolls without slipping on a horizontal plane. A horizontal force is applied to the center of the disk and in a direction parallel to the plane of the disk.

I. Derive Lagrange's equations and find the generalized force.

II. Discuss the motion if the force is not applied parallel to the plane of the disk.

(10 marks)

b. Two points of mass m are joined by a rigid weightless rod of length l, the center of which is constrained to move on a circle of radius a. Express the kinetic energy in generalized coordinates (10 marks)

QUESTION FOUR (20 Marks)

a. Consider the following variation of the twin paradox. A, B, and C each have a clock. In A's reference frame, B flies past A with speed *v* to the right. When B passes A, they both set their clocks to zero. Also, in A's reference frame, C starts far to the right and moves to the left with speed *v*. When B and C pass each other, C sets his clock to read the same as B's. Finally, when C passes A, they compare the readings on their clocks. At this moment, let A's clock read TA, and let C's clock read TC.

(i) Working in A's frame, show that TC = TA/γ,

where $\gamma = \dfrac{1}{\sqrt{1-\dfrac{v^2}{c^2}}}$

ii) Working in B's frame, show again that TC = TA/γ.

iii) Working in C's frame, show again that TC = TA/γ.

(20 marks)

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QUESTION FIVE (20 Marks)

a) Derive the Lorentz's transformations (10 Marks)

b) Briefly discuss the postulates of the theory of relativistic mechanics (10 Marks)