JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

UNIVERSITY EXAMINATION 2013/2014

1ST YEAR, 1ST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE WITH IT

COURSE CODE: SPH 101

TITLE: CLASSICAL MECHANICS

DATE: 26/4/2013 **TIME: 14.00-16.00PM**

DURATION: 2 HOURS

INSTRUCTIONS:

1. **This paper contains two sections (A and B)**
2. **Answer ALL questions in Section A and any Two (2) questions in Section B**
3. **Write ALL answers in the booklet provided**

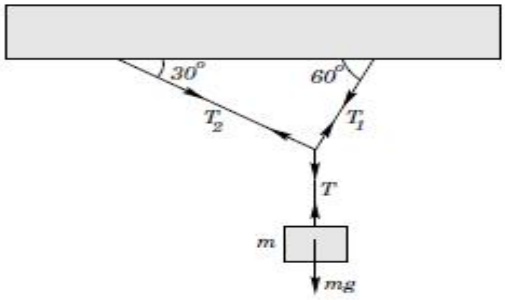
QUESTION ONE: (COMPULSORY) (30 MARKS)

(a) The speed of sound v in a gas might plausibly depend on the pressure p, the density ρ, and the volume V of the gas. Use dimensional analysis to determine the exponents x, y, and z in the formula

$$v = Cp^x\rho^yV^z;$$

where C is a dimensionless constant. Incidentally, the mks units of pressure are kilograms per meter per second squared. (3 marks)

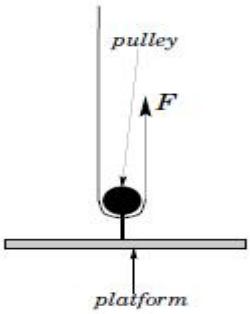
(b) The figure below shows a block of mass m suspended by three strings.



If the system is in equilibrium, show that the tension on the string T_1 is given by

$$T_1 = \frac{\sqrt{3}}{2}mg$$ (3mks)

(c) Consider the diagram. The platform and the attached frictionless pulley weigh a total of 34 N. With what force F must the (light) rope be pulled in order to lift the platform at $3.2 m/s^2$? (3mks)



(d) Consider a body of mass m which is thrown vertically upward with initial velocity *v*. Show that the maximum height it attains is given by;

$$h=\frac{v^2}{2g}$$ (3mks)

(e) Define the following:

(i) Conservative field (2mks)

(ii) Non-conservative force (2mks)

(iii) Work (2mks)

(f) The force required to slowly stretch a spring varies from 0N to 105Nas the spring is extended by 13 cm from its unstressed length. What is the force constant of the spring? What work is done in stretching the spring? Assume that the spring obeys Hooke's law. (2mks)

(g) A man lifts a 30 kg bucket from a well whose depth is 150 m. Assuming that the man lifts the bucket at a constant rate, how much work does he perform? (2mks)

(h) (i) Define *impulsive force.* (1mk)

(ii) A softball of mass m = 0.35 kg is pitched at a speed of u = 12m/s. The batter hits the ball directly back to the pitcher at a speed of v = 21m/s. The bat acts on the ball for t = 0.01 s.

(I) What impulse is imparted by the bat to the ball? (3mks)

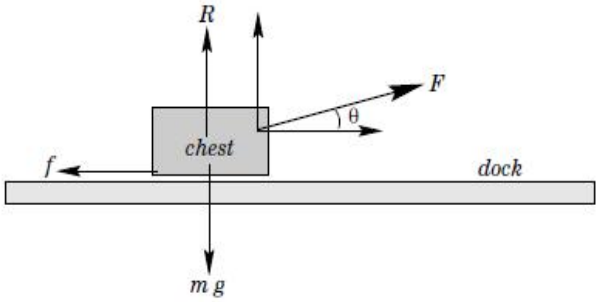
(II) What average force is exerted by the bat on the ball? (2mks)

(i) Civil engineers generally *bank* curves on roads in such a manner that a car going around the curve at the recommended speed does not have to rely on friction between its tires and the road surface in order to round the curve. Suppose that the radius of curvature of a given curve is r = 60 m, and that the recommended speed is v = 40km/h. At what angle θ should the curve be banked? (2mks)

(j) A tire placed on a balancing machine in a service station starts from rest and turns through 5.3 revolutions in 2.3 s before reaching its final angular speed. What is the angular acceleration of the tire (assuming that this quantity remains constant)? (3mks)

QUESTION TWO: (20 MARKS)

(a) A pirate drags a 50 kg treasure chest over the rough surface of a dock by exerting a constant force of 95N acting at an angle of 15^{o} above the horizontal. The chest moves 6m in a straight line, and the coefficient of kinetic friction between the chest and the dock is 0.15, as shown in the figure below.



(i) How much work does the pirate perform? (5mks)

(ii) How much energy is dissipated as heat via friction? (5mks)

(iii) What is the final velocity of the chest? (4mks)

(b) A satellite moves in a circular orbit around the Earth with speed v =6000m/s. The Earth's mass and radius are M= 5.97 x 10^{24} kg and R = 6.378 x 10^{6} m, respectively. Determine: (Take: Gravitational constant, G = 6.67 x $10^{-11}$$Nm^2/kg^2$)

(i) The satellite's altitude above the Earth's surface. (3mks)

(ii) Determine the period of the satellite's orbit. (3mks)

QUESTION THREE: (20 MARKS)

(a) A bullet of mass m = 12 g strikes a stationary wooden block of mass M = 5.2 kg standing on a frictionless surface. The block, with the bullet embedded in it, acquires a velocity of v = 1.7m/s.

(i) What was the velocity of the bullet before it struck the block? (3mks)

(ii) What fraction of the bullet's initial kinetic energy is lost (*i.e.*, dissipated) due to the collision with the block? (4mks)

(b) Two objects slide over a frictionless horizontal surface. The first object, mass $m_1 = 5$ kg, is propelled with speed $v_{i1} = 4.5$m/s toward the second object, mass $m_2 = 2.5$ kg, which is initially at rest. After the collision, both objects have velocities which are directed $\theta = 30^o$ on either side of the original line of motion of the first object.

(i) What are the final speeds of the two objects? (5mks)

(ii) Is the collision elastic or inelastic? Give reason. (2mks)

(c) A bullet of mass m = 10 g strikes a pendulum bob of mass M = 1.3 kg horizontally with speed v, and then becomes embedded in the bob. The bob is initially at rest, and is suspended by a stiff rod of length l = 0.6m and negligible mass. The bob is free to rotate in the vertical direction.

(i) What is the minimum value of v which causes the bob to execute a complete vertical circle? (3mks)

(ii) How does the answer change if the bob is suspended from a light flexible rod (of the same length), instead of a stiff rod? (3mks)

QUESTION FOUR: (20 MARKS)

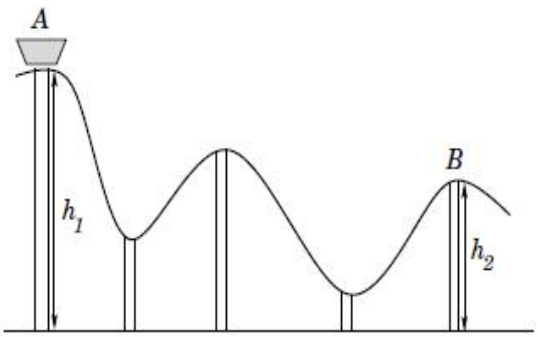
(a) A block attached to a spring executes simple harmonic motion in a horizontal plane with an amplitude of 0.25 m. At a point 0.15m away from the equilibrium position, the velocity of the block is 0.75m/s. What is the period of oscillation of the block? (6mks)

(b) A block of mass m = 4 kg is attached to a spring, and undergoes simple harmonic motion with a period of T = 0.35 s. The total energy of the system is E = 2.5 J.

(i) What is the force constant of the spring? (3mks)

(ii) What is the amplitude of the motion? (3mks)

(c) A roller coaster cart of mass m = 300 kg starts at rest at point A, whose height off the ground is $h_1 = 25$ m, and a little while later reaches point B, whose height off the ground is $h_2 = 7$ m.



(i) What is the potential energy of the cart relative to the ground at point A? (4mks)

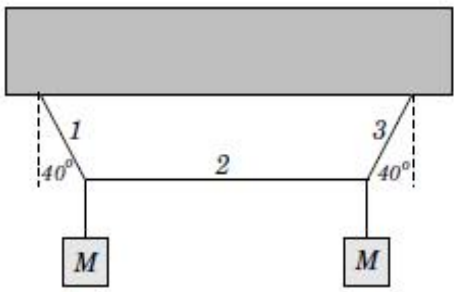
(ii) What is the speed of the cart at point B, neglecting the effect of friction? (4mks)

QUESTION FIVE: (20 MARKS)

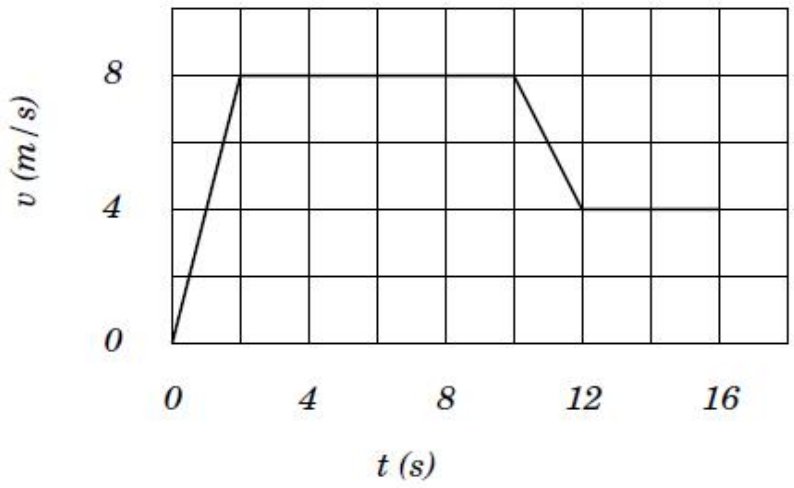
(a) A planet is in circular orbit around a star. The period and radius of the orbit are $T = 4.3 \times 10^7$ s and $r = 2.34 \times 10^{11}$ m, respectively. Calculate the mass of the star. (Take: Gravitational constant, $G = 6.67 \times 10^{-11} Nm^2/kg^2$) (5mks)

(b) Consider the diagram. If the system is in equilibrium, and the tension in string 2 is 50 N, determine the mass M.

(6 mks)



(c) Consider the motion of the object whose velocity-time graph is given in the diagram.



(i) What is the acceleration of the object between times t = 0 and t = 2? (3mks)

(ii) What is the acceleration of the object between times t = 10 and t = 12? (3mks)

(iii) What is the net displacement of the object between times t = 0 and t = 16? (3mks)

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