UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

RE-SIT EXAMINATION 2017/2018

TITLE OF PAPER: MECHANICS

COURSE NUMBER: PHY211

TIME ALLOWED: THREE HOURS

INSTRUCTIONS: ANSWER ANY FOUR OUT OF FIVE QUESTIONS.

EACH QUESTION CARRIES 25 MARKS.

MARKS FOR EACH SECTION ARE IN THE RIGHT HAND MARGIN.

THIS PAPER HAS 6 PAGES INCLUDING THE COVER PAGE.

DO NOT OPEN THE PAPER UNTIL PERMISSION HAS BEEN GIVEN BY THE CHIEF INVIGILATOR.

QUESTION 1

(a) Derive the basic kinematic equation:

$$x = x_0 + v_0 t + \frac{1}{2} a t^2.$$

(5 marks)

(b) Given that $d\hat{r}/dt = \dot{\theta}\hat{\theta}$ and $d\hat{\theta}/dt = -\dot{\theta}\hat{r}$, show that in Polar coordinates

$$\vec{a} = (\ddot{r}\hat{r} - r\dot{\theta}^2)\hat{r} + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\hat{\theta}.$$

(8 marks)

(c) A particle moves outwards along a spiral. Its trajectory is given by $r = A\theta$, where $A = 1/\pi$ m/rad. θ increases in time according to $\theta = \alpha t^2/2$, where is a constant.

(i) Show that the radial acceleration is zero when $\theta = 1/\sqrt{2}$.

(6 marks)

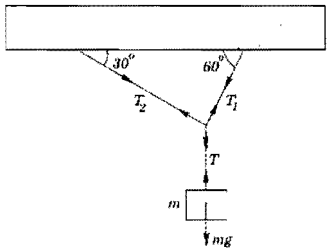
(ii) At what angle do the radial and tangential acceleration have equal magnitude?

(6 marks)

QUESTION 2

(a) A block of mass m is suspended by three strings as shown below. Assuming that the block is in equilibrium, find the tension T_1, T_2 and T.

(6 marks)



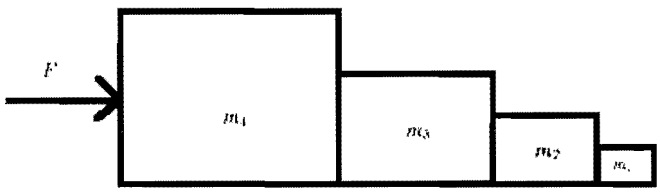
(b) Four blocks (m_1 = 1kg, m_2 = 2.00kg, m_3 = 3.00kg and m_4 = 4.00kg) are in contact on a horizontal table. A horizontal force F = 18.0 N is applied to the mass m_4.

(i) Draw a force diagram for each block.

(3 marks)

(i) Find the magnitude of the force of contact F_{12} between m_1 and m_2, F_{23} between m_2 and m_3 and F_{34} between m_3 and m_4.

(9 marks)



(c) A 75 kg man stands on a spring scale in an elevator. During the first 3 seconds of motion from rest, the tension T in the hoisting cable is 8300 N. Total mass of elevator, man, and scale is 750 kg.

(i) Find the reading N of the scale in Newton during this interval.

(4 marks)

(ii) Find the upward velocity v of the elevator at the end of the 3 seconds.

(3 marks)

QUESTION 3

(a) Two blocks M_a and M_b are stacked on top of each other as shown below. Assume $M_b > M_a$. The two blocks are pulled from rest by a massless rope passing over a pulley. The pulley is accelerated at rate A. Block M_b slides on the table without friction. The coefficient of static friction between M_a and M_b is μ_s.

(i) If the blocks do not slip relative to each other, what are their acceleration?

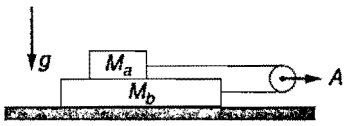
(5 marks)

(iii) Find Tension on the rope assuming the blocks do slip.

(5 marks)

(ii) Assume that the blocks do slip relative to each other. Determine each block's horizontal acceleration as a function of M_a, M_b, μ_s, g, A. Work in an inertial reference frame.

(5 marks)



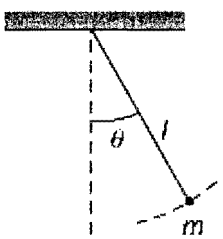
(b) A simple pendulum of length ℓ, with mass M, and corresponding weight $W = Mg$ is shown below. The mass moves in a circular arc in a vertical plane, with angle θ from the vertical.

(i) Write the equation of motion.

(3 marks)

(ii) Find $\theta(t)$ and the oscillation period T assuming that the pendulum never swings far from the vertical so that $\theta \ll 1$.

(7 marks)



QUESTION 4

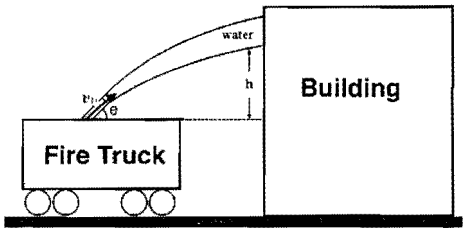
(a) A fire truck pumps a stream of water on a burning building at a rate K kg/s. The stream leaves the truck at angle θ with respect to the horizontal and strikes the building horizontally at height h above the nozzle.

(i) Find v_0 as a function of g, h, θ.

(9 marks)

(ii) What is the magnitude of the force on the truck due to the ejection of the water stream?

(3 marks)



(b) The mass per unit length of a non-uniform rod of length ℓ is given by $\lambda = A cos(\pi x/2\ell)$, where x is position along the rod, $0 \leq x \leq \ell$.

(i) What is the mass M of the rod?

(5 marks)

(ii) What is the coordinate X of the center of mass?

(8 marks)

QUESTION 5

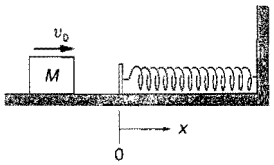
(a) A block of mass M slides along a horizontal table with speed v_0. At $x = 0$ it hits a spring with spring constant k and begins to experience a friction force. The coefficient of friction is $\mu = bx$, where b is a constant.

(i) Find the distance the block will travel before it first come momentarily to stop.

(8 marks)

(ii) Find the work done when the block first come momentarily to rest.

(8 marks)



(b) Sand runs from a hopper at constant rate dm/dt onto a horizontal conveyor belt driven at constant speed v by a motor. Find the power needed to drive the belt.

(9 marks)