UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

RE-SIT EXAMINATION 2018/2019

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:

$$v^2 = v_0^2 + 2a_0(x - x_0).$$

(7 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

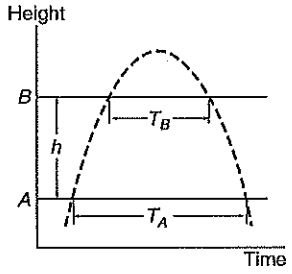
$$\vec{a} = (\ddot{r}\hat{r} - r\dot{\theta}^2)\hat{r} + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\hat{\theta}.$$

(8 marks)

(c) The acceleration of gravity can be measured by projecting a body upward and measuring the time that it takes to pass two given points in both directions. Show that if the time the body takes to pass a horizontal line A in both directions is T_A, and the time to go by a second line B in both directions is T_B, then, assuming that the acceleration is constant, its magnitude is

$$g = \frac{8h}{T_A^2 - T_B^2},$$

where h is the height of line B above line A.



(10 marks)

QUESTION 2

(a) Two masses, M_1 and M_2, are connected by a string that passes over a pulley. The pulley is accelerating upward at rate A, as shown, and the gravitational force on each mass is $W_i = M_i g$.

(i) Draw a force diagram for each block.

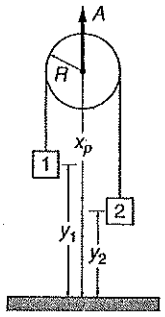
(4 marks)

(ii) Find the tension T in the string.

(8 marks)

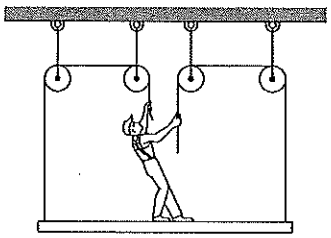
(iii) Find the rate at which the masses accelerate.

(6 marks)



(b) A painter of mass M stands on a scaffold of mass m and pulls himself up by two ropes which hang over pulleys, as shown. He pulls each rope with force F and accelerates upward with a uniform acceleration a. Find a, neglecting the fact that no one could do this for long.

(7 marks)



QUESTION 3

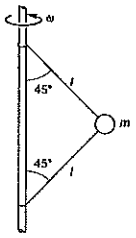
(a) A mass m is connected to a vertical revolving axle by two strings of length ℓ, each making an angle of 45° with the axle, as shown. Both the axle and mass are revolving with angular velocity ω. Gravity is directed downward.

(i) Draw a force diagram for m.

(4 marks)

(ii) Find the tension in the upper string, T_{up}, and lower string, T_{low} in terms of m, ℓ, ω and g.

(8 marks)



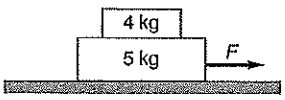
(b) Mass $M_A = 4$kg rests on top of mass $M_B = 5$kg that rests on a frictionless table. The coefficient of friction between the two blocks is such that the blocks just start to slip when the horizontal force F applied to the lower block is 27 N. Suppose that now a horizontal force is applied to the upper block.

(i) Draw a force diagrams.

(4 marks)

(ii) What is its maximum value for the blocks to slide without slipping relative to each other?

(9 marks)



QUESTION 4

(a) 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.

(10 marks)

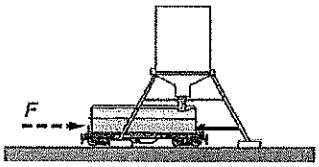
(b) An empty rail car of mass M starts from rest under an applied force F. At the same time, sand begins to run into the car at steady rate b from a hopper at rest along the track.

(i) Find the velocity when a mass of sand m has been transferred to the rail car in terms of F, m, b and m. The problem can be solved in only two steps, but use the *mass and momentum transport* method.

(10 marks)

(ii) Apply your solution to the case when $M_0 = 400$ kg, $b = 15$ kg/s and $F = 80$N to find the velocity at time $t = 10$ s.

(5 marks)



QUESTION 5

A chain of total mass M and length l is suspended vertically with its lowest end touching a scale. The chain is released and falls onto the scale. (Neglecting the size of individual links.)

(a) Find the speed of each infinitesimal bit striking the scale.

(8 marks)

(a) Find the change in momentum of each new infinitesimal piece.

(8 marks)

(c) What is the reading of the scale when a length of chain, x, has fallen?

(9 marks)