UNIVERSITY OF RUHUNA

BACHELOR OF SCIENCE GENERAL DEGREE – LEVEL I (SEMESTER I) EXAMINATION – SEPTEMBER-OCTOBER- 2018

SUBJECT: Physics **TIME: Three (03) hours**

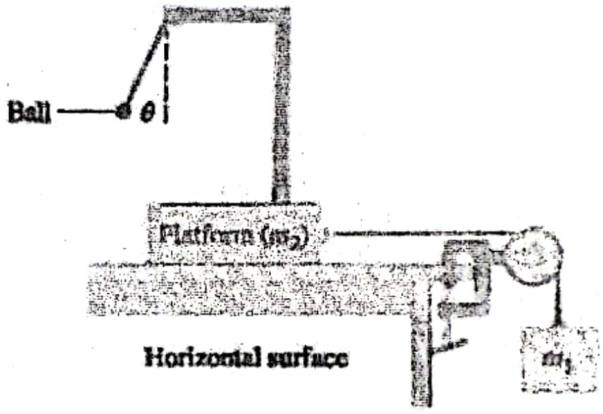
COURSE UNIT: PHY 1114

Answer only 05 questions

Part II

(All symbols have their usual meaning)

Figure shows an experimental setup prepared to measure the acceleration of a mass system. The angle θ that the thread supporting the light ball of mass m, where m is negligible compare to the m_1 and m_2, makes with vertical is read by an electronic display. There is no friction anywhere.



a) Draw any two pairs of forces relating to the Newton's 3rd law in the system. [02 marks]

b) If $m_1 > m_2$ find the acceleration of the system. [03 marks]

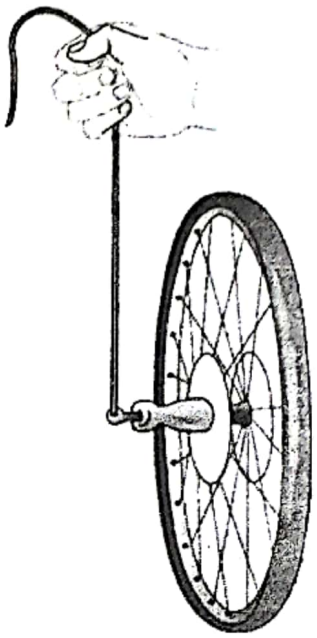
c) How is θ related to the acceleration of the system? [04 marks]

d) If m_2=250 kg and m_1=1250 kg what is the reading of the display in degrees? [04 marks]

e) If you vary m_1 and m_2, what would be the largest angle reading you could read? Explain your answer. [04 marks]

f) If the ball is immersed in a transparent liquid of density greater than the density of the ball, what would happen to the ball? Explain briefly. [08 marks]

2. As shown in the figure a bicycle wheel is held by a string connecting to one end of the axle. The other end of the axle is initially held and then released.



a) Sketch the diagram on your answer sheet and show all forces acting on the system just after releasing the holding end of the axle.

[02 marks]

b) If the wheel is not rotated around its axle, what would happen to the wheel under the forces given in part (a). Describe the motion of the wheel with reasons for your answer.

[04 marks]

c) If the wheel is rotated around the axle in clockwise direction (relative to the string connected end of the axle) with angular velocity Ω after releasing, describe the motion of the wheel giving relevant expressions.

[05 marks]

d) What changes on the precession of the bicycle wheel is expected under the following conditions? Explain your answers with necessary expressions.

i. When the angular velocity Ω of the wheel is low.

ii. If the wheel is rotated in opposite direction (anticlockwise direction).

[06 marks]

e) If the bicycle wheel takes 4.0 s for one revolution of precession, calculate the angular speed of the wheel in terms of revolutions per minute.
Radius of the bicycle wheel is 30 cm and the string is connected 4 cm from the centre of gravity of the wheel. Assume that the total mass of the wheel is concentrated in the outer ring of the wheel.

[08 marks]

3.

(a)

i. What is meant by conservative force?
Give one example each for a conservative force and non-conservative force.

[02 marks]

ii. For a particle moving under a conservative force, $\bar{F}$, write down a relationship between $\bar{F}$ and its scalar potential U.

[02 marks]

iii. If a particle undergoes a non-conservative force in addition to conservative forces, show that the work done by non-conservative force is equal to the change in total mechanical energy of the system.

[04 marks]

(b) A wrecked satellite of mass m, which is at rest with respect to the earth, is freely falling from the altitude h towards the earth surface under the gravitational attraction.

i. What are the conservative and non-conservative forces acted on the moving satellite?

[02 marks]

ii. If only conservative forces/force are/is considered, using energy relations find an expression for the velocity of the dead satellite at the earth surface (take radius and the mass of the earth as R_E and M respectively).

[04 marks]

iii. Draw the variation of potential energy function with the distance r from the surface of the earth.

[02 marks]

iv. When the satellite is lively orbiting around the earth show that the kinetic energy of the satellite should be equal to the half of the potential energy.

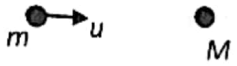
[04 marks]

4.

(a) What is meant by the Centre of Mass reference frame of a system of particles?

[02 marks]

(b) A particle of mass m moving with velocity u collides with another mass M, which is at rest.



i. Write down the velocity of the C.O. M frame of above system.

[02 marks]

ii. Find the velocity of each mass reference to the C.O.M frame.

[02 marks]

iii. Find the velocity of each particle after the collision with reference to the C.O.M frame.

[04 marks]

iv. Find the velocity of each particle after the collision with reference to the lab frame.

[04 marks]

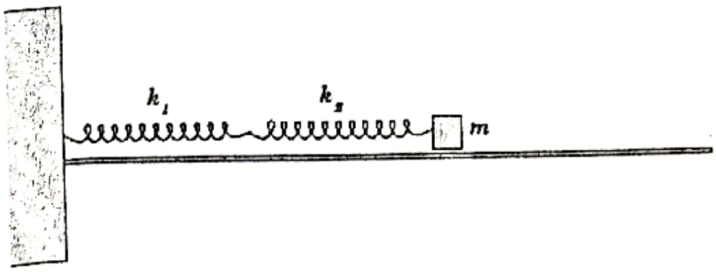
v. Hence show that the fractional energy loss by mass m is given by, $\frac{4mM}{(m+M)^2}$

[04 marks]

vi. Hence discuss the condition needed to transfer the maximum energy from incoming particle to the target particle after the collision.

[02 marks]

5. A block of mass m is attached to two springs of spring constants k_1 and k_2, as shown below, and slides over a horizontal frictionless surface.



(a). Write down an expression for the effective force constant, K_{eff}, for a single spring that could replace the two springs system. Hence show that the block exhibits a simple harmonic motion with period $T = 2\pi\sqrt{\frac{m(k_1 + k_2)}{k_1 k_2}}$. [08 marks]

(b). Write down the expressions for total energy in terms of amplitude and also using kinetic and potential energies. Hence derive the equation for velocity of the mass m. Take x_1 and x_2 as the extensions of the two springs of force constants k_1 and k_2 respectively.

[08 marks]

(c). If $m = 3$ kg, $k_1 = 1200$ N/m and $k_2 = 400$ N/m, calculate the period of oscillation of the system. [05 marks]

(d). If total energy of the system is 2.5 J, find the amplitude of the motion.

[04 marks]

6.

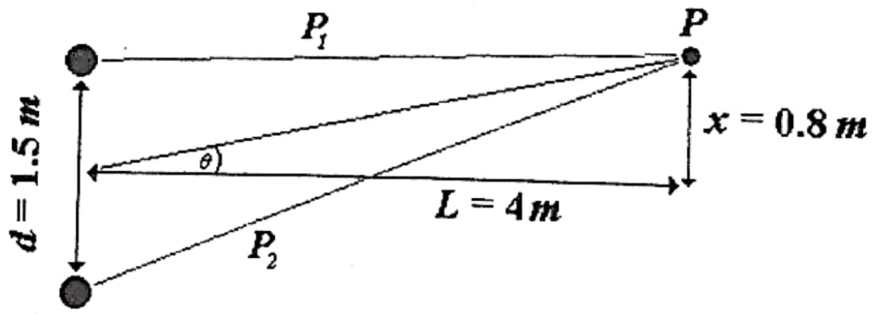
(a) What is meant by constructive interference and destructive interference?

[06 marks]

(b) What should be the values of phase differences between the two waves for constructive and destructive interference?

[04 marks]

(c) Two speakers emitting sound at 550 Hz are 1.5 m apart. The first destructive interference takes place 4m to the right and 0.8m above the line of symmetry, as shown in the Figure.



i. Write down the equations for path lengths P_1 and P_2 using the terms L, x and d. [04 marks]

ii. Hence write down the relationship between the path length difference and wavelength for the first destructive interference. [03 marks]

iii. Calculate the velocity of sound. [03 marks]

iv. Find the value for velocity of sound using small-angle approximation $d \sin\theta = (n + 1/2)\lambda$. [03 marks]

v. Compare your results. [02 marks]