SOUTH EASTERN KENYA UNIVERSITY

UNIVERSITY EXAMINATIONS 2016/2017

FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN (PHYSICS/ELECTRONICS/GEOLOGY/METEOROLOGY) AND BACHELOR OF EDUCATION (SCIENCE)

SPH 201: MECHANICS II

6TH DECEMBER, 2016 TIME:8.00-10.00 A.M

INSTRUCTIONS TO CANDIDATES

- This paper consists of FIVE questions.
- Answer question **ONE** and any other **TWO** questions.
- Question **ONE** carries 30 mark while the other **TWO** questions carry 20 marks each
- Use the following constants where necessary

  $g=9.81 m/s^2$

  $G = \mathbf{6.67408 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}}$

  Radius of Mercury 5.79×10^{10} m

  Radius of Earth 6.37×10^{6} m

  Mass of the Earth 5.97×10^{24}kg

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Define simple harmonic motion [2 marks]

b) In 2004 astronomers reported the discovery of a large Jupiter-sized planet orbiting very close to the star HD 179949 (hence termed a "hotJupiter"). The orbit was just 1/ 9 the distance of Mercury from our sun, and it takes the planet only 3.09 days to make one orbit (assumed to be circular).

i. What is the mass of star? [3 marks]

ii. How fast is this planet moving [3 marks]

c) An oscillating body does not maintain constant amplitude throughout its time of oscillation. Explain? [2 marks]

d) Define the following terms as used in SHM [3 marks]

i. Frequency

ii. Period

iii. Amplitude

e) Using an illustration diagram in the form of graph sketch. Explain the difference in the un-damped, heavily damped and critically damped motion effects on the oscillator [8 marks]

f) A string fixed at x=0 and x= l is given initial velocity $y_t(x,0)=v$, and zero initial displacement, $y(x,0)=0$. Find $y(x,t)$ (5 marks)

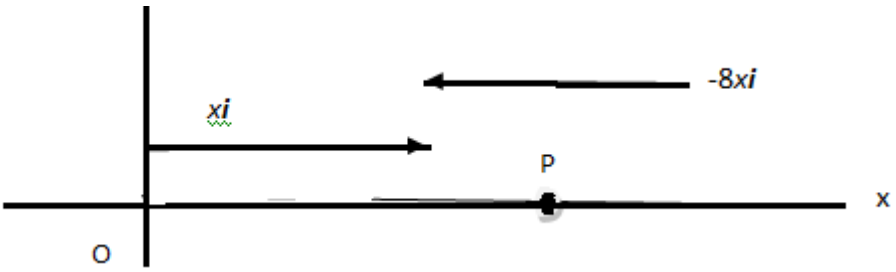
Given that $y(x,t)=\sum_{n=1}^{\infty}\sin\frac{n\pi x}{L}\left(A_n\sin\frac{n\pi ct}{L}+B_n s\cos\frac{n\pi ct}{L}\right)$

g) Explain the working principles of the Michelson –Morley experiment [4 marks]

QUESTION TWO (20 MARKS)

a. A particle p of mass 4kg moves along the x axis attracted towards origin O by a force whose magnitude is numerically equal to 8x shown in the **fig 1** below. If it is initially at rest at x=20m

Fig 1



Calculate

i. The differential equation and initial conditions describing the motion (3 marks)

ii. The position of the particle at any time (3 marks)

iii. The velocity of the particle at any time (3 marks)

iv. The amplitude, period and frequency of the vibration (3 marks)

b. Express in symbols the equation of conservation of energy for a simple harmonic oscillator

[6 marks]

c. state two conditions necessary for SHM to take place [2 marks]

QUESTION THREE (20 MARKS)

a. State the Newton's law of gravitation and give the mathematical equivalent of it

[2 marks]

b. A typical adult human has a mass of about 70.0kg

i. what force does a full moon exert on such human when it is directly overhead with its centre 378,000km away [mass of the moon is 7.35×10^{22} kg] [3 marks]

ii. compare this force with that exerted on the human by the earth [mass of the earth is 5.97×10^{24} kg] [3 marks]

c. Find the minimum initial velocity needed to eject a projectile of mass *m* up and away from the gravitational attraction of the earth as shown in the fig 2 below [6 marks]

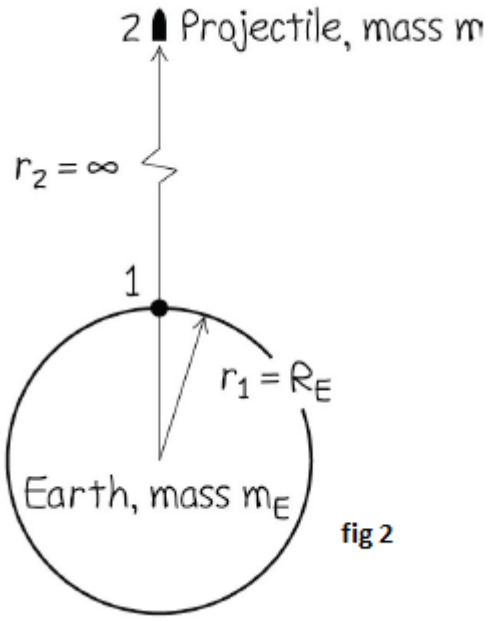


fig 2

d. Calculate the earth's gravity force on a 75.0 kg astronaut who is repairing the Hubble Space Telescope 600 km above the earth's surface, and then compare this value with his weight at the earth's surface. [6 marks]

QUESTION FOUR (20 MARKS)

a) Define coupled oscillations [1 mark]

b) Two identical harmonic oscillators (with masses m and natural frequency ω_o) are coupled such that by adding to the system a mass m, common to both oscillators the equations of the motion becomes

$$\ddot{x}_1 + \frac{m}{M}\ddot{x}_2 + \omega_o^2 x_1 = 0$$

$$\ddot{x}_2 + \frac{m}{M}\ddot{x}_1 + \omega_o^2 x_2 = 0$$

Solve this pair of equations and obtain the frequencies of the normal modes of the system

c) Proof that $x^2 + y^2 + z^2 - c^2t^2$ is an invariant under Lorentz transform [6 marks]

d) Two particles come towards each other with a speed of 0.7c with respect to the laboratory. What the relative speed [3 marks]

e) The length of a rocket ship is 100m long on the ground. During its flight, the apparent length is found to be 99m when measured from the ground calculate its speed [4 marks]

QUESTION FIVE (20 MARKS)

a) When a simple pendulum of length l is displaced through an angle θ from equilibrium point and released, its starts to swing. Using an illustrative diagram indicate and label forces acting on a pendulum at the position of its displacement [3 marks]

b) If there are no damping forces acting on the pendulum, and it executes simple harmonic motion, show that for the small angle θ the frequency f of oscillation and periodic time T of the pendulum would be given by the following

$$f = \frac{1}{2\pi}\sqrt{g/l} \qquad \text{(5marks)}$$

$$T = \frac{1}{2\pi}\sqrt{l/g} \qquad \text{(2 marks)}$$

c) Prof that the force $F = -kx\vec{i}$ acting on a simple oscillator is conservative, where the symbols have their usual meanings [4 marks]

d) The displacement x (cm) of an oscillating particle varies with time t (seconds) according to the following equation $x = 2\cos\left(0.5\pi t + \left(\frac{\pi}{3}\right)\right)$. Calculate;

Amplitude, angular frequency, maximum velocity and acceleration [6 marks]