University of Ghana

School of Engineering Sciences
First Semester Examinations: 2015/2016
Level 100: BSc. Engineering
FAEN 109: General Physics (3 credits)

Answer all questions

Time Allowed: $2\frac{1}{2}$ hours Total Marks: 100

(a) Distinguish between vibrations and waves. [4 marks]

(b) What is a simple harmonic motion (SHM)? [2 marks]

(c) How do you determine, whether a vibrating body is undergoing SHM? [2 marks]

(d) Explain any two applications of SHM in engineering. [4 marks]

(e) A particle moves as a function of time as follows:

$$x = 3.0\,m \times \cos\left(2.0\,\frac{radian}{s}\,t + \frac{\pi}{3}\right)$$

where distance is measured in meters and time in seconds.

(i) For this simple harmonic motion, determine the following: (α) amplitude, (β) frequency (γ) angular frequency and (δ) period. [4 marks]

(ii) At what earliest time does the particle reach the (α) equilibrium point? (β) turning point? [4 marks]

(iii) At what later time does the particle reach the (α) equilibrium point and (γ) turning point? [4 marks]

(a) Ocean waves of a period of 10 s have a speed of 16 m/s.

(i) Calculate the

(α) wavelength of these waves.
(β) horizontal distance between a wave crest and a wave trough.

(ii) If the wave height is 1.2 m measured from trough to crest, what is the maximum velocity of a point on the water surface at a given horizontal position? Assume the waves are harmonic. [10 marks]

(b) (i) Why is modulation of waves necessary?
(ii) Explain briefly what is meant by group velocity and phase [6 marks]

3) A 0.500 kg object connected to a light spring with a spring constant of 20.0 N/m oscillates on a frictionless horizontal surface.

(a) Calculate the total energy of the system and the maximum speed of the object if the amplitude of the motion is 3.00 cm.

(b) What is the velocity of the object when the displacement is 2.00 cm? Compute the kinetic and potential energies of the system when the displacement is 2.00 cm.

[10 marks]

4) The end of a long string of mass per unit length μ is knotted to the beginning of another long string of mass per unit length μ' (The tension in these strings are equal). A harmonic wave travels along the first string toward the knot. This incident wave will be partially transmitted into the second string, and partially reflected. The frequencies of all these waves are the same with the knot at x = 0, we can write the following expression for the incident, reflected and transmitted waves, respectively:

$$y_1 = A_{in}\cos(kx - \omega t)$$

$$y_2 = A_{ref}\cos(kx + \omega t)$$

$$y_3 = A_{trans}\cos(k'x - \omega t)$$

Show that

$$A_{ref} = \frac{k - k'}{k + k'}A_{in} = \frac{\sqrt{\mu} - \sqrt{\mu'}}{\sqrt{\mu} + \sqrt{\mu'}}A_{in}$$

$$A_{trans} = \frac{2k}{k + k'}A_{in} = \frac{2\sqrt{\mu}}{\sqrt{\mu} + \sqrt{\mu'}}A_{in}$$ [15 marks]

{Hint: At x=0, the displacement of the string must be continuous; $y_1 + y_2 = y_3$. If not, the string would break at the knot. Furthermore, the slope of the tangent to the string must be continuous; $\frac{dy_1}{dx} + \frac{dy_2}{dx} = \frac{dy_3}{dx}$, if not the string would have a kink and the massless knot would receive an infinite acceleration.}

7. 5) (a) Sketch and explain how electric field is generated.

(b) Using both Coulomb's and Gauss's law. Show that the electric field ge large flat sheet, such as a sheet of paper, carrying a uniform charge densi coulomb per square meter is same as $E = \frac{\sigma}{2\varepsilon_O}$

(c) Explain the role of electric field in storage of charges in capacitors.

(d) What is electromagnetic (EM) field theory? Explain any two engineerir applications of EM field.