PHYS 260 (Spring 2010)
General Physics: Oscillations, Heat and Electricity

Prof. K. Agashe - Sections 0201, 0202, 0203, 0204 and 0205

Written Homeworks

It is necessary to show the details of the derivation and not just the final answer for all problems.

1 Homework 0 (due before turning in Homework 1)

Sign the Honor Pledge (which covers all assignments):

"I pledge on my honor that I will not give or receive any unauthorized assistance on all examinations, quizzes and homework assignments in this course."

2 Homework 1 (due in lecture on Thursday, February 4)

Consider the simple harmonic motion of a block attached to a spring on a horizontal surface (assume no damping to begin with). At $t = 0$, the potential energy in the spring is 25% of the maximum potential energy during this motion. Moreover, the kinetic energy of the block is decreasing with time at $t = 0$ and, at $t = 2.0$ s, the kinetic energy becomes zero for the 1st time (after $t = 0$).
(i) What is the frequency of this motion?
(ii) What is the spring constant if the mass of the block is 2 kg?
(iii) If the total energy of the system is 10^{-2} J, then what is the amplitude of the motion?
(iv) Next, a drag force is added with a damping constant of 0.2 kg/s. At what time will the energy in the motion reduce to 25% of the energy at $t = 0$?

3 Homework 2 (due in lecture on Thursday, February 18)

Consider the hydraulic lift in Fig. 15.19 of the textbook. A student stands on the piston on the left-hand-side whose diameter is 0.3 m and balances a 2160 kg car placed on the right-hand side piston whose diamater is 1.8 m.
(i) Deterimine the mass of the student. Assume that the two pistons are at the same level.
(ii) Solve problem 15.43 of textbook (2nd edition).
(iii) A second student of mass 70 kg joins the first student on the left-hand-side piston. Determine the distance through which the the car is lifted.

Assume density of liquid in the hyrdraulic lift is 900 kg/m^3 (typical one for oil).

4 Homework 3 (due in lecture on Thursday, February 25)

A small homemade firework goes off 3 meters about the surface of the water where a person is diving. The diver is 10 meters below the surface of the water.
(a). How much time passes from the instant the firework goes off until the diver sees it?
(b). How much time passes from the instant the firework goes off until the diver hears it?
When the firework goes off, another individual is traveling on a boat moving at a speed of 30 km per hour away from the firework. That person is standing on the upper deck of the boat, also 3 m above the surface.
(c). If the person on the boat hears a sound with frequency 200 Hz, what is the actual frequency of the firework's sound?
(d). If the frequency of the light emitted by the fireworks is 5×10^{14} Hz, what is the wavelength of this light as seen by the diver?
For values of numerical constants, refer to the textbook (assume temperature of the air is 20°C).

5 Homework 4 (due in lecture on Thursday, March 4)

Consider two loudspeakers (emitting sound waves of the same amplitude and wavelength of 15m) and an observer located in the $x-y$ plane, with the two loudspeakers being at $(2m, 0)$ and $(-2m, 0)$, respectively, and the observer being at $(0, 3m)$ *initially*.
(i) Suppose the intensity of the combined sound heard by the observer is *same* as that of the sound from each loudspeaker by itself. Determine the possible values of the *inherent* phase difference between the two sound waves.
(ii) The observer then moves along the x-direction to reach the point $(2m, 3m)$. For each of the possible cases mentioned in part (i), determine whether the interference at this new location of the observer is maximum constructive or maximum destructive or something in-between.

6 Homework 5 (due in lecture on Thursday, March 25)

10 grams of oxygen gas at an initial pressure of 2.5 atm. and a temperature of 25° C undergoes an isochoric cooling until the pressure is halved.
(a). What is the temperature at the end of the process?
(b). How much work has been done in this step?
Next, the gas is isothermally compressed to its original pressure.
(c). What is the volume at the end of the compression?
(d). How much work has been done in this step?
Finally, the gas undergoes an isobaric expansion to its original volume.

(e). How much work has been done in this step?
(f). Show the full 3 step process on a $p - V$ diagram.

7 Homework 6 (due in lecture on Thursday, April 1)

A iron block of mass 10 g at some initial temperature and 10 g of ice at an initial temperature of $-40°$C are added to 1 g of water which is initially at 20°C. This system is then allowed to reach thermal equilibrium. Specific heats of ice, water and iron are 2090 J/kg K, 4190 J/kg K and 449 J/kg K, respectively and heat of fusion of water is 3.33×10^5 J/kg.
(i) If the initial temperature of the iron block is 1000°C, then what is the equilibrium temperature of this system?
(ii) Calculate the *maximum* intial temperature of the iron block such that the equilibrium temperature is *not* above 0°C.
(iii) Calculate the *minimum* intial temperature of the iron block such that the equilibrium temperature is not *below* 0°C.

8 Homework 7 (due in lecture on Thursday, April 8)

An ice-making machine inside a refrigerator operates in a Carnot cycle. It takes heat from liquid water at 0.0°C and rejects heat to a room at a temperature of 22.3°C. Suppose that liquid water with a mass of 74.8 kg at 0.0°C is converted to ice at the same temperature. Take the heat of fusion for water to be $L_f = 3.34 \times 10^5$ J/kg.
(A) How much heat $|Q_H|$ is rejected to the room? Express your answer in joules to four significant figures.
(B) How much energy (in joules) must be supplied to the device?

9 Homework 8 (due in lecture on Thursday, April 15)

Two point charges are placed on the x-axis. The first charge, $q_1 = 8.00$ nC, is placed a distance 16.0 m from the origin along the positive x-axis; the second charge, $q_2 = 6.00$ nC, is placed a distance 9.00 m from the origin along the negative x-axis.
(A). Calculate the electric field (in terms of x and y-components) at point A, located at coordinates (0 m, 12.0 m).
An unknown additional charge q_3 is now placed at point B, located at coordinates (0 m, 15.0 m).
(B) Find the magnitude and sign of q_3 needed to make the total electric field at point A equal to zero.

10 Homework 9 (due in lecture on Tuesday, April 27)

A uniform electric field exists in the region between two oppositely charged parallel plates 1.59 cm apart. A proton is released from rest at the surface of the positively charged plate

and strikes the surface of the opposite plate in a time interval 1.57×10^{-6} s.
(i) Find the magnitude of the electric field.
(ii) Find the speed of the proton at the moment it strikes the negatively charged plate.
(iii) Calculate the surface charge density on each plate.

11 Homework 10 (due in lecture on Tuesday, May 4)

A spherical capacitor is formed from two concentric spherical conducting shells separated by vacuum. The inner sphere has a radius of 12.4 cm, and the outer sphere has a radius of 15.0 cm. A potential difference of 120 V is applied to the capacitor.
(i) What is the capacitance of the capacitor?
(ii) What is the magnitude of the electric field at radius 12.6 cm (i.e. just outside the inner sphere)?
(iii) What is the magnitude of the electric field at radius 14.7 cm (i.e., just inside the outer sphere)?

12 Homework 11 (due in lecture on Tuesday, May 11)

Problem 32.66 of textbook with the following *additional* questions:
(i) What is the (magnitude and direction of) current flowing through the 12 V battery (on the left)?
(ii) What is the magnitude of the voltage (potential difference) across the 4 Ω resistor on the right? Is the upper or lower end of the resistor at a higher potential than the other end?