Physics 121 - CH 13,14,16,17 Review

August 3, 2009

Use this test to help review for our upcoming test. It might be helpful to work through the problems carefully and then try doing them again without using your book. Remember, the best way to solve physics problems is to develop a method and follow it every time. For the actual test you can bring a notecard, your calculator and I will provide a copy of table 10.2.

Useful Numbers $R_{Sun-Earth} = 1.5 \times 10^{11}$m
$R_{Sun-Mars} = 2.28 \times 10^{11}$m
$G = 6.67 \times 10^{-11} Nm^2/kg^2$
$M_{Sun} = 1.99 \times 10^{30}$kg
$R_{Sun} = 6.96 \times 10^{8}$m
$c = 2.99 \times 10^{8}$m/s
speed of sound = 343m/s
$\sigma = 5.67 \times 10^{-8} Wm^{-2}K^{-4}$

1. Equation 1 describes the position as a function of time for a simple harmonic oscillator.

$$x(t) = Bcos(\omega t + \frac{\pi}{4}) \tag{1}$$

a) What is the velocity as a function of time?
b) What is acceleration at t = 10s? B=5cm, $\omega = 24s^{-1}$

2. A particle undergoes simple harmonic motion with amplitude 25cm and maximum speed 4.8m/s. Find
a) the angular frequency,
b) the period,
c) the maximum acceleration.

3. Compare the angular frequency of the circular harmonic motion of the Sun-Earth system and a hypothetical system where a mass equal to the mass of the Earth is hanging by a cable, the same length as the distance between the Sun and the Earth and acting as a simple pendulum where the force of gravity is equal to that due to the Sun at the radius of the Earths orbit.

4. The intensity or flux of light from the Sun on the surface of the Earth is about 1365 Wm^{-2}. By what factor would you need to increase the area of a solar panel array in order to collect the same amount of energy on Mars as on Earth?

5. A fire truck's siren at rest wails at 1400Hz; standing by the roadside as the truck approaches, you hear it a t 1600hz. How fast is the truck going?

6. If you place a tray of marshmallows in a microwave and turn it on while not allowing the tray to rotate, standing waves will be formed from the microwaves and melt the marshmallows only where the waves constructively interfere. You measure the distance between these melted spots and find an average value of 6.1cm. This corresponds to half the wavelength of the microwaves. What frequency is the microwave operating at?

7. Your body should be at about 98°F or 37°C. If you are wearing a goose down coat that is 5cm thick, what is the rate of heat loss when you are in 0°C weather. Assume you can model your torso as a box 0.4m x 0.6m x 0.25m. The thermal conductivity of goose down is 0.043 W/mK

8. An O5 type supergiant star emits energy at a rate of $4.45 \times 10^{32} W$. It also has a radius of 1.48×10^{10}m. What temperature is the surface of this star if we treat it as a black body (e=1)?

9. The specific heat of aluminum is 900 $Jkg^{-1}K^{-1}$. If you have 5000J of heat available and you want to change the temperature of a chunk of aluminum by 15°C, how massive can the chunk of aluminum be?

10. A plastic water bottle has a volume of about 1/2 a liter at a temperature of 293K. What volume will a sealed empty bottle be crushed to if it is taken to the bottom of the ocean where the pressure is 200 times greater than at the surface and it is 20K colder?

11. How many Joules of heat do you need to remove from 1kg of water at 10°C to freeze it into a block of ice at -10°C?
$c_{ice} = 2.05 kJ/kgK$
$c_{water} = 4.184 kJ/kgK$
$L_f = 334 kJ/kg$

12. You want to develope a thermal valve. You have a sheet of material 0.1m wide and when the water temperature increases by 50°C you want it to expand to 0.12m wide and seal off the pipe it is inside. What must the coefficient of linear expansion be for this material?