Prof. Anchordoqui

Problems set # 12 **Physics 168**

1. A spider of mass 0.3 g waits in its web of negligible mass. A slight movement causes the web to vibrate with a frequency of about 15 Hz. (a) Estimate the value of the sping stifness constant k for the web. (b) At what frequency would you expect the web to vibrate if an insect of mass 0.1 g were trapped in addition to the spider?

2. A bug on the surface of a pond is observed to move up and down a total vertical distance of 6 cm, from the lowest to the highest point as a wave passes. If the ripples decrease to 4.5 cm, by what factor does the bug's maximum kinetic energy change?

3. A bungee jumper (with mass 65 kg) jumps from a high platform in Kuta Beach (Bali, Indonesia). After reaching his lowest point, he oscillates up and down, hitting a low point eight more times in 38 s. He finally comes to rest 25 m below the level of the platform. Calculate the spring stiffness constant and the unstretched length L of the bungee cord.

4. A tsunami of wavelength 250 km and velocity 750 km/h travels across the Pacific Ocean. As it approaches Hawaii, people observe an unsual decrease of sea level in the harbors. Approximately how much time do they have to run safety?

5. Inchy, an inchworm, is inching along a cotton clothesline. The 25-m-long clothesline has a mass of 1 kg and is kept taut by a hanging object of mass 10 kg as shown in Fig. 1. Gaby is hanging up her swimsuit 5 m from one end when she sees Inchy 2.5 cm from the opposite end. She plucks the line sending a terrifying 3-cm-high pulse towards Inchy. If Inchy crawls at 1 in/s, will he get to the end of the clothesline before the pulse reaches him?

6. In one of the original Doppler experiments, a tuba was played on a moving flat train car at a frequency of 75 Hz, and a second identical tuba played the same tone while at rest in a railway station. What frequency was heard if the train car approaches the station at a speed of 10 m/s.

7. Batman has sent a signal to the batcave calling for his batfriends to cover his escape. Answering the signal, a bat which is nearby starts flying at 5 m/s. As it flies, the bat emits an ultrasonic sound wave with frequency 30 kHz towards the tall wall of the building. What frequency does the bat hear in the reflected wave?

8. A factory whistle emits sound of frequency 570 Hz. When the wind velocity is 12 ms from the north what frequency will observers hear who are located, at rest, (a) due north, (b) due south, (c) due east, (d) due west, of the whistle? What frequency is heard by a cyclist heading (e) north or (f) west, toward the whistle at 15 m/s. Assume $T = 20°\text{C}$.

9. A bat flies toward a moth at speed 6.5 m/s while the moth is flying toward the bat at speed of 5 m/s. The bat emits a sound wave of 51.35 kHz. What is the frequency of the wave detected by the bat after the wave reflects off the moth?

10. A bat emits a series of high frequency sound pulses as it approaches a moth. The pulses are approximately 70 ms apart, and each is about 3 ms long. How far away can the moth be detected by the bat so that the echo from one chirp returns before the next chirp is emitted?

11. A supersonic plane flying due east at an altitude of 15 km passes directly over point P. The sonic boom is heard at point P when the plane is 22 km east of point P. What is the speed of the plane? (See Fig. 1)

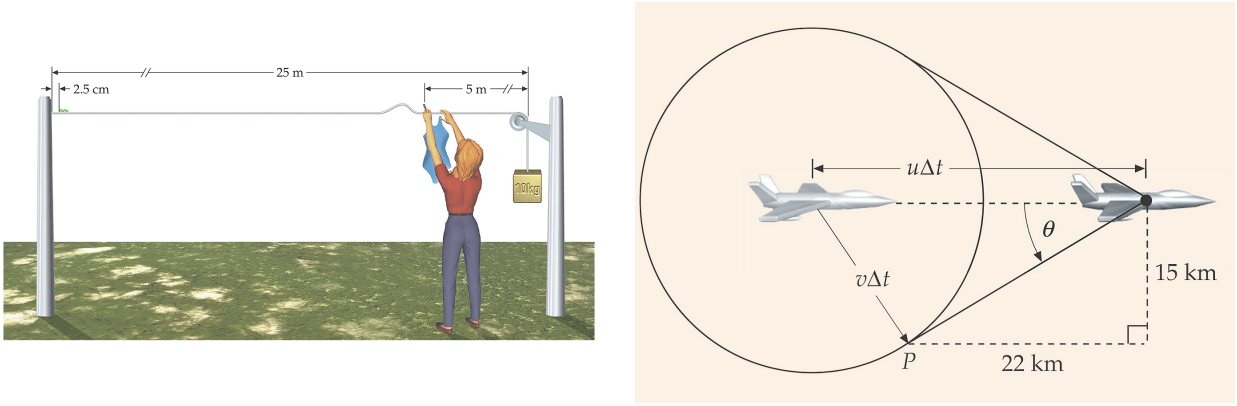

Figure 1: The situation in problem 5 and problem 11.

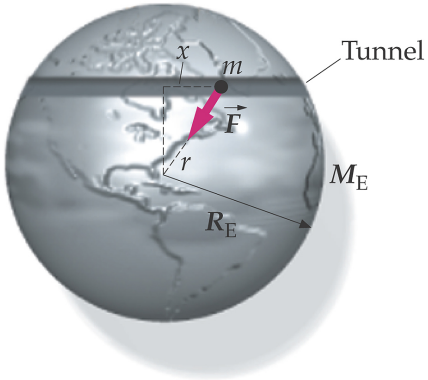

Figure 2: The situation in problem 13.

12. The wave function

$$y(x,t) = 0.03 \text{ m} \sin[(2.2 \text{ m}^{-1})x - (3.5 \text{ s}^{-1})t]$$

is for a harmonic wave on a string. In what direction does this wave travel and what is its speed? (b) Find the wavelength, frequency, and period of this wave. (c) What is the maximum displacement of any point on the string? (d) What is the maximum speed of any point on the string?

13. A straight tunnel is dug through Earth as shown in Fig. 2. Assume that the walls of the tunnel are frictionless. (a) The gravitational force exerted by Earth on a particle of mass m at a distance r from the center of Earth when $r < R_\oplus$ is $F_r = (GmM_\oplus/R_\oplus^3)r$. Show that the net force on a particle of mass m at a distance x from the middle of the tunnel is given by $F_x = -(GmM_\oplus/R_\oplus^3)x$ and that the motion of the particle is therefore simple harmonic motion. (b) Show that the period of the motion is independent of the length of the tunnel and is given by $T = 2\pi\sqrt{R_\oplus/g}$. (c) Find its numerical value in minutes.