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Problems set # 10 | **Physics 167** | April 25, 2023

1. Calculate the wavelength (i) of a 60-Hz EM wave, *(ii)* of a 93.3-MHz FM radio wave, and *ii)* of a beam of visible red light from a laser at frequency 4.74×10^{14} Hz.

2. Radiation from the Sun that reaches the Earth's surface (after passing through the atmosphere) transports energy at a rate of about 1000 W/m^2. Estimate the pressure and force exerted by the Sun on your outstretched hand.

3. Some science fiction writers have described solar sails that could propel interstellar spaceships. Imagine a giant sail on a spacecraft subjected to radiation pressure from our Sun. *(i)* Explain why this arrangement works better if the sail is highly reflective rather than highly absorptive. *(ii)* If the sail is assumed highly reflective, show that the force exerted by the sunlight on the spacecraft's sail is given by $F_{\rm rad} = \frac{P_\odot A}{2\pi r^2 c}$, where $P_\odot$ is the power output of the Sun (3.8×10^{26} W), A is the surface area of the sail, r is the distance from the Sun, and c is the speed of light. (Assume that the area of the sail is much larger than the area of the spacecraft so that all the force is due to radiation pressure on the sail, only. *(iii)* Using a reasonable value for A, compute the force on the spacecraft due to the radiation pressure and the force on the spacecraft due to the gravitational force of the Sun on the spacecraft. Does this result imply that such a system will work? Explain your answer.

4. A pulsed laser fires a 1000 MW pulse that has a 200 ns duration at a small object that has a mass equal to 10.0 mg and is suspended by a fine fiber that is 4.00 cm long. If the radiation is completely absorbed by the object, what is the maximum angle of deflection of this pendulum? [*Hint*: Think of the system as a ballistic pendulum and assume the small object was hanging vertically before the radiation hit it.]

5. A dish antenna having a diameter of 20 m receives (at normal incidence) a radio signal from a distant source as shown in Fig. 1. The radio signal is a continuous sinusoidal wave with amplitude $E_{\rm m} = 0.2\mu$V/m. Assume the antenna absorbs all the radiation that falls on the dish. *(i)* What is the amplitude of the magnetic field in this wave? *(ii)* What is the intensity of the radiation received by the antenna? *(iii)* What is the power received by the antenna? *(iv)* What force is exerted by the radio waves on the antenna?

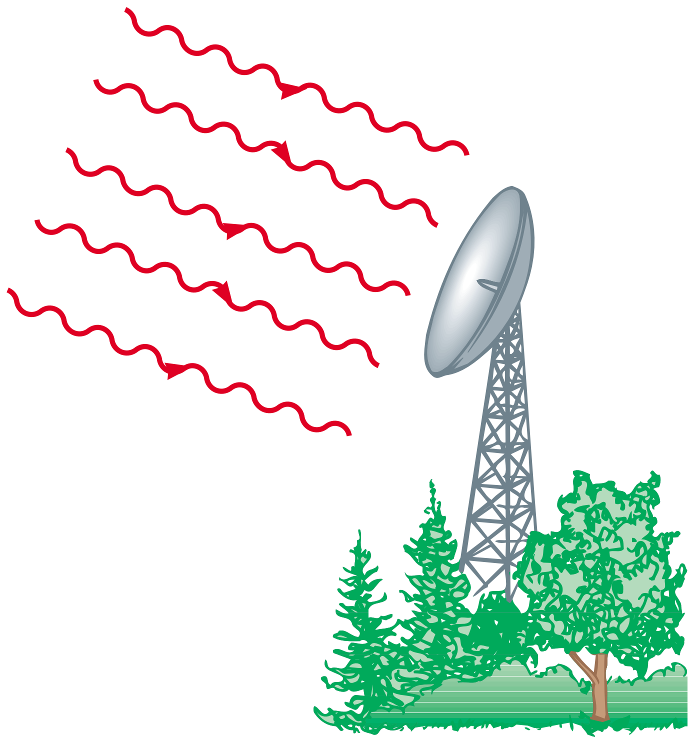

Figure 1: Problem 5.