Below you are given choices for several groups of problems. INDICATE CIRCLING THE PROBLEM NUMBER, which ones you are doing. The others, even if attempted, will be ignored.

Do one of the following two problems:

1-Imagine that a aluminum belt is wound around the Earth’s equator (R=6.38x10⁶ m) and that the Earth is a perfect sphere. The linear thermal expansion coefficient is α=2.4x10⁻⁵. If the Earth’s temperature changes from 20 °C to 21 °C, then what is the height above the ground that the belt will rise above the ground?

2-What is the height of a waterfall if the temperature rises by 1 °C as if falls from the top to the bottom assuming that all the mechanical energy is transformed into heat. The specific heat capacity of water is 4190 J/Kg K.

Do two of the following three problems:

3-What are the angular frequency of oscillations for each of the three arrangements below:

4. A horizontal spring-block system is in SHM with parameters A, φ₀ = 0, ω. At time t₁ (for which ωt₁ = φ₁) a blob of putty with mass m is dropped straight down on the block, sticking to it. What is the
new amplitude of oscillation and its new angular frequency? The mass of the block is M.

5. For a potential energy of the form $U(x) = U_0|x|^\alpha$, with $\alpha > 0$, find out what is the period of oscillation for a particle of mass $m$ with an initial amplitude $A$. Give the result in a form that leaves only a definite integral to be done. What is the dependence of the period on the amplitude? Comment on the trends of the oscillation frequency with amplitude and for different powers $\alpha$.

Do one of the following two problems:

6. A 2-Kg sphere, when falling through air, reaches a terminal velocity of 75 m/s. This sphere, when suspended from an ideal lossless spring, oscillates in air with a period of $T=0.30$ s. (a) What is the spring constant? (b) What time interval is required for the amplitude to decrease to one half of the value at the beginning of the interval?

7. A 50 Kg ball is attached to a one end of a 1 m cord that has a mass of 0.10 Kg. The other end of the cord is attached to a ring that can slide frictionless on a horizontal shaft, as shown in the diagram. A horizontal blow is delivered to the cord and excites the fundamental vibration with a maximum transverse velocity of 15 m/s. Assume that the ball remains essentially stationary as the cord vibrates.

(a) What is the frequency of the fundamental vibration
(b) What is the amplitude of the motion
(c) If the blow is delivered as an impulse to a stationary rod, show that the wave function for the cord is $y(x,t) = A\sin(\pi x/2L)\sin(\omega t)$, where the ball is located at $x=0$.
(d) What is the energy of vibration?
(e) Determine the period the pendulum of the hanging ball and compare it with the vibrating string. Is it reasonable to assume that the hanging ball remains stationary?
Do three of the four problems that follow:

8. An object is located in a fixed position in front of a screen. A thin lens, placed between the object and the screen, produces a sharp image on the screen when it is in either of two positions that are 10 cm apart. The sizes of the images in the two situations are in the ratio 3:2. (a) What is the focal length of the lens? (b) What is the distance from the screen to the object?

9. You want to design a pinhole camera with optimal resolution. Your box is a cube of 50 cm on the side. You drill a small circular hole and the opposite side is used as a screen where the photographic film is placed. What is the diameter needed to optimize the resolution if the average wavelength of the image is 500 nm? Make sure you present a reason for your answer.

10. A Raleigh refractometer, shown in the diagram below, is a device used in precision measurements of refraction indexes of gases. Two identical glass cells, A and B, are placed behind a pair of narrow slits that are illuminated by a plane wave of blue-green light (wavelength of 550 nm). Each cell has an inside length l=2.500 cm, and l<<D. When the cells are evacuated, the optical path lengths are identical and the central fringe is located at P. Gas is slowly admitted into cell A and the central fringe is observed to move upward. At a pressure of 1.00 atm and 0°C, the central fringe is at Q, a distance equal to 20.5 fringe spacings from P. Determine the refraction index of the gas.

11. Two polarizers are positioned with their transmission axes parallel. A third polarizer is placed between the original two pieces. Derive an expression for the intensity of light transmitted through the three-piece combination as a function of the angle between either of the end polarizers and the middle one. The incident light is unpolarized and has intensity I₀.