1. **(20%)** "Physics is the study of matter and energy, and their relationships."
   a. Define 'matter' and 'energy.'
   b. Explain the relationship of matter and energy with an example.
   c. There are several kinds of energy. Give one example for each of the following kind of energy and explain briefly (you can find examples from your daily life).
   1) heat energy, 2) mechanical energy, 3) chemical energy, 4) electrical energy.

2. **(10%)** The dimension of a rectangular bar is measured to have a length of (12.3 ± 0.2) cm, a width of (4.50 ±0.10) cm, and a height of (6.75 ± 0.05) cm.
   a. Find the sum of the length, the width, and the height of the bar, and the uncertainty in the calculated sum.
   b. Also, find the volume of the bar and the uncertainty in the calculated volume.

3. **(10%)** On fast highways or car-racing tracks, the outside edge of curves is raised (banking, 傾斜). Such *banking* prevents the vehicle from slipping sideways if there is not enough friction to provide the centripetal force (向心力). A car of mass 1000 kg rounds a circular curve of radius 10 m that is banked at 37° to the horizontal. The road is slippery, so the coefficient of static friction is only 0.1. Find the maximum safe speed at which the car can travel.

4. **(10%)** A load of 102 kg is supported by a wire of length 2 m and cross-sectional area 0.1 cm^2. The wire is stretched by 0.22 cm. Find the tensile stress, tensile strain, and Young's modulus for the wire.

5. **(5%)** The two ends of a steel rod are fixed. What is the thermal stress in the rod when the temperature decreases by 80 K? Young's modulus of steel is 200 GPa and coefficient of linear thermal expansion of steel is $11.7 \times 10^{-6}\ K^{-1}$.

6. **(10%)** The equation of a wave is

   $$y(x, t) = 0.05 \sin\left[\frac{\pi}{2}(10x - 40t) - \frac{\pi}{4}\right] \qquad \text{(in meters, m)}$$

   where (x, y) are the coordinates of a point of the wave, t is time.
   a. Find the wavelength, the frequency, and the wave velocity.
   b. Find the particle velocity and acceleration at $x = 0.5$ m and $t = 0.05$ s.

7. **(10%)** A point charge $q_1 = -9\ \mu C$ is at x = 0, while $q_2 = 4\ \mu C$ is at $x = 1$ m. At what point ($x = ?$ m), besides infinity (∞), would the net force on a positive charge q_3 be zero?

8. **(10%)** White light is incident normally on a glass plate (refractive index n = 1.52) that is coated with a film of MgF_2 (n = 1.38). For what minimum thickness of the film will the yellow light of wavelength 580 nm (in air) be missing in the reflected light?

9. **(15%)**
   a. What is the energy carried by a quantum of light whose wavelength $\lambda = 300$ nm?
   b. A sodium (Na) surface is illuminated with this light ($\lambda = 300$ nm). Find the kinetic energy of the ejected photoelectrons. [The work function (minimum binding energy of an electron) for sodium metal is 2.46 eV]
   c. Find the cutoff wavelength for sodium. (cutoff wavelength: the maximum wavelength of an incident light to produce photoelectrons)

   (Planck's constant = 6.626×10^{-34} J·s, 1 eV = 1.6×10^{-19} J)