

*** Show all steps if there are calculations. ***

*** If equations are used in the answers, clearly define all parameters in them. ***

1. (a) What are the current definitions of "one kilogram" (mass), "one second" (time), and "one meter" (length)? (b) Show how force, acceleration, and energy can be defined in terms of these three fundamental physical quantities. (12%)
2. A rectangular bar has 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. (12%)
3. A long-jumper leaves the ground at an angle of 30° to the horizontal and at a speed of 10 m/s. (a) How far does he jump? (Assume that the motion of the long-jumper is equivalent to that of a particle.) (b) What is the maximum height reached? (8%)
4. What are Issac Newton's three laws of motion? (12%)
5. A mass of 0.5 kg connected to a light spring of force constant 20 N/m oscillates on a horizontal, frictionless surface. (a) Calculate the total energy of the system and the maximum speed of the mass if the amplitude of the motion is 3 cm. (b) What is the velocity of the mass when the displacement is equal to 2 cm? (c) Compute the kinetic and potential energies of the system when the displacement equals 2 cm. (12%)
6. A steel railroad track has a length of 30 m when the temperature is 0°C . (a) What is its length on a hot day when the temperature is 40°C ? (The linear thermal expansion coefficient of steel is $11 \times 10^{-6} \text{ }^\circ\text{C}^{-1}$.) (b) Suppose the ends of the rail are rigidly clamped at 0°C so as to prevent expansion. Calculate the thermal stress set up in the rail if its temperature is raised to 40°C . (The Young's modulus of steel is $20 \times 10^{10} \text{ N/m}^2$.) (c) If the rail has a cross-sectional area of 30 cm^2 , calculate the force of compression in the rail, in Newton and kg. (12%)
7. What are (a) Coulomb's law, (b) Gauss' law, (c) Kirchhoff's rules, and (d) Maxwell's equations? (16%)
8. What are (a) the law of reflection, (b) the law of refraction, (c) the index of refraction, and (d) the total internal reflection? (16%)