

Physics Qualifying Examination

Friday, August 24th, 2001

This examination has questions from six areas of physics. The time allotted is 3 hours and 30 minutes. Make sure that you attempt each problem. The examination will be graded based on your approach to solving the problem and your application of physical principles.

Answer each of the problems on a separate sheets of paper.

$$1/4\pi\epsilon_0 = 9.0 \times 10^9 \text{ Vm/C}$$

$$\mu_0 = 1.26 \times 10^{-6} \text{ H/m}$$

$$e = 1.60 \times 10^{-19} \text{ C}$$

$$m_e = 0.511 \text{ MeV}/c^2$$

$$h = 6.6 \times 10^{-34} \text{ Js} = 4.14 \times 10^{-15} \text{ eVs}$$

$$c = 3.00 \times 10^8 \text{ m/s}$$

$$E_0 = 13.61 \text{ eV}$$

$$R = 1.0974 \times 10^7 \text{ m}^{-1}$$

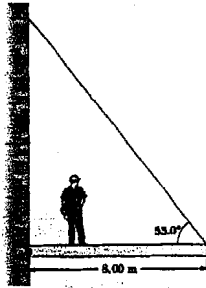
$$1\text{eV} = 1.60 \times 10^{-19} \text{ J}$$

$$\text{mass of proton} = 1.007276 \text{ u}$$

$$\text{mass of neutron} = 1.008665 \text{ u}$$

Mechanics

A) A uniform horizontal beam of length 8.00 m and weight 200 N is attached to a wall by a pin connection. Its far end is supported by a cable that makes an angle of 53.0° with the horizontal. If a 600 N person stands two meters from the wall, find the tension in the cable.

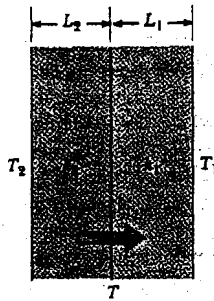


B) An object moves in a smooth straight tunnel dug between two points on the Earth's surface. Show that the object moves with simple harmonic motion. Assume the Earth's density is uniform.

II Thermodynamics

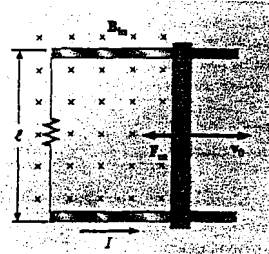
A) Consider a gas at a temperature of 2500 K whose atoms can occupy only two energy levels separated by 1.5 eV. Determine the ratio of the number of atoms in the higher energy level to the number in the lower energy level.

B) Two slabs of thickness L_1 and L_2 are in thermal conductivities k_1 and k_2 are in thermal contact with each other. The temperature of the outer surfaces are T_1 and T_2 and $T_2 > T_1$. Determine the temperature at the interface and the rate of thermal energy transfer through the slabs in the steady-state condition.



III Electricity and Magnetism

A) A bar of mass m and length l moves on two frictionless parallel rails in the presence of a uniform magnetic field directed into the paper. The bar is given an initial velocity v_0 to the right and is released. Find the velocity of the bar as a function of time.



B) A spherical capacitor consists of a spherical conducting shell of radius b and charge $-Q$ that is concentric with a smaller conducting sphere of radius a and charge Q . Find its capacitance.

IV Optics

A) Find the image distance and describe the image for a converging lens of focal length 10.0 cm when an object is placed.

i) 10 cm from the lens.

ii) 30 cm from the lens.

B) A fiber optic cable ($n=1.50$) is submerged in water ($n=1.33$). What is the critical angle for the light to stay inside the cable?

V Math Physics

A) Find x , y , and z by Cramer's rule:

$$x + 4y - z = 1$$

$$x + y + z = 0$$

$$2x + 3z = 0$$

B) Find the particular solution of the differential equation.

$$\frac{d^2 y}{dx^2} - 3 \frac{dy}{dx} - 4y = 2 \sin x$$

VI Modern Physics

A) Calculate the binding energy of the deuteron, which consists of a proton and a neutron, given that the mass of a deuteron is 2.013553 u.

B) A pulsed ruby laser emits light having a wavelength of 694.3×10^{-9} m. For a 14×10^{-12} s pulse containing 3.0 J of energy, find

- a) the physical length of the pulse as it travels through space
- b) the number of photons in it.