

Physics Qualifying Examination

Friday, August 18, 2000

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.

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

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

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

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

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

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

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

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

I Mechanics

A 5.0 m long ladder leans against a wall at a point 4.0 m above the ground. The ladder is uniform and has a mass of 12.0 kg. Assume the wall is frictionless, but the ground is not.

A) Determine the forces exerted on the ladder by the ground and the wall.

B) If the coefficient of static friction between the ladder and the ground is 0.40, how far up the ladder can a 58 kg person climb before the ladder slips.

II Thermodynamics

A) Derive the following relationship between pressure and volume for an adiabatic expansion in an ideal gas,

$$PV^\gamma = \text{constant},$$

where

$$\gamma = \frac{C_P}{C_V}$$

B) An ideal mono-atomic gas is allowed to expand slowly until its pressure is reduced to half its original value. By what value does the volume change if the process is a) adiabatic b) isothermal?

III Electricity and Magnetism

Charge is distributed uniformly over a thin circular disk of radius R . The charge per unit area is σ . Calculate the electric field and potential due to the disk, at a point P on the axis of the disk, at a distance z away from the center.

IV Optics

A) A point source of light is placed at a distance of 25.0 cm from the center of a glass sphere ($n=1.5$) of radius 10.0 cm. Find the location of the image.

B) A person looks vertically down in a 1.0 m pool filled with water ($n = 1.33$). How deep does the pool appear to be?

V Math Physics

A) Solve the following system of equations for x , y , and z .

$$2x - y + 2z = 2$$

$$x + 10y - 3z = 5$$

$$-x + y + z = -3$$

B) Solve the following differential equation.

$$y'' - 4y' + 4y = 0, \text{ where}$$

$$y(0) = 3, \text{ and } y'(0) = 1$$

VI Modern Physics

Describe in a few sentences the following:

A) The ultraviolet “catastrophe” and Planck’s description of blackbody radiation.

B) The wavefunction in quantum mechanics.

C) The Bohr atom.

D) Determine the wavelengths of the first three transitions in the Balmer series for hydrogen. How would the wavelengths change for an ion with $Z=2$ (He^+)?