University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER II (RESIT) EXAMINATION – 2010/2011

PHYC 10150

Physics for Engineers I

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Time Allowed: 2 Hours

Instructions for Candidates

Candidates should attempt **four** questions, **two** question from Section A and **two** questions from Section B. All questions carry equal marks. The marks allocated to each part of a question are indicated in brackets.

Instructions for Invigilators

Non-programmable calculators are permitted.

Section A

1. i) Three identical pucks on horizontal air table have repelling magnets. They are held together and then released simultaneously. Each has the same speed at any instant. One puck moves due west. What is the direction and velocity of each of the other two pucks? (15 marks)

   ii) A radio-controlled model airplane has a momentum given by [(-0.75 kg m/s^3)t^2+ (3.0 kg m/s)] **i** + [(0.25 kg m/s^2)t] **j**. What are the *x*-, *y*-, and *z*-components of the net force on the airplane? (10 marks)

2. i) A 0.100 kg steel bob is tied to a string with length 1.20 m, and the other end of the string is tied to a rigid support. The ball is held straight out horizontally from the point of support, and is then released. What is the speed of the bob at the lowest point of its motion? What is the tension in the string at that point? (10 marks)

   ii) Energy is to be stored in a 70.0 kg flywheel in the shape of a uniform solid disk with radius R = 1.20 m. To prevent structural failure of the flywheel, the maximum allowed radial acceleration of a point on its rim is 3500 m/s^2. What is the maximum kinetic energy that can be stored in the flywheel? (15 marks)

3. i) A 2.00 kg frictionless block is attached to an ideal spring with force constant 300 N/m. At t = 0 the spring is neither stretched nor compressed and the block is moving in the negative x direction at 12.0 m/s. Find the amplitude and the phase angle and write an equation for the position of the block as a function of time. (15 marks)

   ii) A 42.5 kg chair is attached to a spring and allowed to oscillate. When the chair is empty it takes 1.30 s to make a complete vibration. But with a person sitting on it, with her feet off the floor, the chair now takes 2.54 s for one cycle. What is the mass of the person? (10 marks)

Section B

4. i) The total lung volume of a typical engineering student is 5.00 L. A student fills her lungs with air at an absolute pressure of 1 bar. Then, holding her breath, she compresses her chest cavity, decreasing the lung volume to 4.50 L. What is the pressure of the air in her lungs then? Assume that the temperature of the air remains constant and that the air can be treated as an ideal gas. (10 marks)

   ii) Initially, the rms speed of the atoms of a monatomic ideal gas is 500 m/s. The volume of the container is reduced by a third while the pressure of the gas is doubled. The number of moles of the gas is kept constant. What is the final rms speed of the atoms? (15 marks)

5. i) A 1.50 m wire has a mass of 8.70 g and is under a tension of 120 N. The wire is held rigidly at both ends and set into oscillation. What is the speed of waves on the wire? What is the frequency of the waves that produce one-loop and two-loop standing waves? (10 marks)

ii) On the planet Schurr a piloted helicopter is flying toward a stationary spaceship at 25.0 m/s while emitting an audible signal at a frequency of 1200 Hz. The detector at the spaceship receives a tone of 1240 Hz. Determine the speed of sound at the planet Schurr. (15 marks)

6. i) A slit 0.10 mm wide is illuminated by light of wavelength 660 nm. We see a diffraction pattern on a screen 1.00 m away. What is the distance between the second and third diffraction minima on the same side of the central diffraction maximum? (10 marks)

ii) A thin layer of ice (n = 1.309) floats on the surface of water (n = 1.333) in a bucket. A ray of light from the bottom of the bucket travels upward through the water. What is the largest angle with respect to the normal that the ray can make at the ice-water interface to still be able to pass through? (15 marks)

Auxiliary formulae

$$a \sin\theta = m\lambda$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\omega = \sqrt{\frac{k}{m}}$$

$$PV = nRT$$

$$v = f\lambda$$

$$K = \frac{I\omega^2}{2}$$

$$I_{disk} = MR^2/2$$

$$v = \sqrt{\frac{3RT}{M}}$$

$$v = \sqrt{\frac{T}{\mu}}$$

$$f' = f\,\frac{v \pm v_D}{v \pm v_S}$$

Recommended Values of Physical Constants and Conversion Factors

(*Sources*: 2006 CODATA recommended values; http://physics.nist.gov/constants)

speed of light in vacuum, c = 299 792 458 (exact) m s^{-1}

electric (permittivity) constant, ε_0 = 8.854 187 817… × 10^{-12} (exact) F m^{-1}

magnetic (permeability) constant, μ_0 = 12.566 370 614… × 10^{-7} (exact) N A^{-1}

(unified) atomic mass unit, u = 1.660 538 782(83) × 10^{-27} kg

alpha particle mass (in u) = 4.001 506 179 127(62) u

atomic mass unit energy equivalent = 1.492 417 830(74) × 10^{-10} J

atomic mass unit energy equivalent (in MeV) = 931.494 028(23) MeV

Avogadro constant, N_A = 6.022 141 79(30) × 10^{23} mol^{-1}

Bohr radius, a_0 = 0.529 177 208 59(36) × 10^{-10} m

Bohr magneton, μ_B = 927.400 915(23) × 10^{-26} J T^{-1}

Boltzmann constant, k = 1.380 6504(24) × 10^{-23} J K^{-1}

classical electron radius, r_e = 2.817 940 2894(58) × 10^{-15} m

Compton wavelength of the electron, λ_C = 2.426 310 2175(33) × 10^{-12} m

deuteron mass (in u) = 2.013 553 212 724(78) u

electron mass (in u), m_e = 5.485 799 0943(23) × 10^{-4} u

elementary charge, e = 1.602 176 487(40) × 10^{-19} C

molar mass of carbon-12 = 12 × 10^{-3} (exact) kg mol^{-1}

neutron mass (in u), m_n = 1.008 664 915 97(43) u

Newtonian constant of gravitation, G = 6.674 28(67) × 10^{-11} m^3 kg^{-1}

nuclear magneton, μ_N = 5.050 783 24(13) × 10^{-27} J T^{-1}

Planck constant, h = 6.626 068 96(33) × 10^{-34} J s

proton mass (in u), m_p = 1.007 276 466 77(10) u

universal gas constant, R = 8.314 472 471 J mol^{-1} K^{-1}

Stefan-Boltzmann constant, σ = 5.670 400(40) × 10^{-8} W m^{-2} K

triton mass (in u) = 3.015 500 7134(25) u

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