

CORK INSTITUTE OF TECHNOLOGY
INSTITIUID TEICNEOLAIOCHTA CHORCAI

Semester 2 Examinations 2010/2011

School: SCIENCE

Programme Title:

Bachelor of Science (Honours) in Environmental Science and Sustainable Technology, Year 1

Bachelor of Science (Honours) in Instrument Engineering, Year 1

Bachelor of Science in Applied Physics and Instrumentation, Year 1

Bachelor of Science in Applied Biosciences, Year 1

Programme Code: SESST_8_Y1
SINEN_8_Y1
SPHYS_7_Y1
SBIOS_7_Y1

Module Title: Physics

Module Code: **PHYS6012**

External Examiner(s): Dr V. Casey, Dr S. Daly, Mr. E. Burke

Internal Examiner(s): Ms C. Devaney
Dr A. O'Connor

Instructions: Answer any **four** questions. All questions carry equal marks.

Duration: 2 Hours

Sitting: Autumn 2011

Requirements for this examination: Log tables.

- 1 (a) An air gun launches a projectile vertically upwards with a speed of 320 m/s at a clay pigeon. If an impact speed of 280 m/s is required for the projectile to shatter the target, what is the maximum height the target may be at for this to occur? How long will it take the bullet to reach the target? [8 marks]
- (b) A skater of mass 62 kg at rest on ice catches a bag of mass 7 kg travelling at 15 m/s. At what speed will she move off? [8 marks]
- (c) What is meant by (i) *work* (ii) *potential energy*? Give two examples of forms of potential energy.
A block of mass 80 kg rests on a floor. If it takes a force of 500 N to just move the block, what is the coefficient of friction between the block and the floor? [7 marks]

- 2 (a) Discuss the conditions necessary to observe interference for light and explain how these conditions are met in Young's double-slit experiment. Show that the condition for constructive interference for slits of separation d is given by

$$d \sin \theta = m\lambda \quad (m = 0, 1, 2, 3, \dots) \quad [11 \text{ marks}]$$

- (b) What is meant by (i) the *amplitude* (ii) the *frequency* of a wave? [4 marks]
- (c) Sketch the diffraction pattern from a single slit and a circular aperture and hence state the Rayleigh criterion for resolution. The Messenger probe will orbit Mercury at a height of 200 km above the surface. What size camera would be required to resolve features of size 5 m on the planet's surface? (Take $\lambda = 550 \text{ nm}$.) [10 marks]
- 3 (a) Give an account of environmental radioactivity. [13 marks]
- (b) Explain the terms (i) *isotope* (ii) *atomic number*.
Silicon-32 (^{32}Si) decays with a half-life of 172 years. What mass of it is required to give an activity of $2.8 \times 10^9 \text{ Bq}$? What will be the activity after 500 years? (Avogadro's number is $N_A = 6 \times 10^{23} \text{ mol}^{-1}$.) [12 marks]
- 4 (a) Explain how an a.c. generator works. What factors affect (i) the *size* (ii) the *frequency* of the induced voltage? [10 marks]
- (b) Sketch the magnetic field surrounding a long straight conductor. What current flowing in a long straight wire will produce a magnetic field of magnitude $10 \mu\text{T}$ at a perpendicular distance of 40 cm from the wire. (Take $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$.) [7 marks]
- (c) A coil of radius 10 cm with 200 turns is placed perpendicular to a uniform magnetic field of 0.2 T. Calculate the emf induced in the coil if the field is (i) doubled in 0.1 s and (ii) reduced to zero in 0.1 s. [8 marks]

- 5 (a) Distinguish between gauge pressure and absolute pressure. Give the SI unit for pressure and one other common pressure unit. Explain how pressure is defined in molecular terms and hence show that, for an ideal gas in a box of volume V ,

$$pV \propto T$$

where T is the absolute temperature.

[8 marks]

- (b) Water enters a pipe of diameter 2.9 cm at a speed of 8.5 m/s. If the pipe narrows to 1.7 cm, with what speed does it leave? [8 marks]
- (c) Give an account of capillary action. How does the height of the column of liquid depend on the width of the tube? [9 marks]

6 ***Answer part (a) and THREE other parts.***

- (a) Light from a monochromatic source passes through double slits of separation 0.2 mm and the interference pattern is projected onto a screen 1.2 m away. If the seventh fringe is 2.5 cm from the centre of the pattern, find the wavelength of the light. [7 marks]
- (b) A pile-driver of mass 60 kg is used to drive stakes into the ground. If it falls from a height of 2 m in each downward stroke and there are 3 strokes per second, what power is transferred to the stakes? [6 marks]
- (c) For the following radioactive decays, identify the type of decay and the unknowns A and X: (i) ${}^{238}_{92}\text{U} \rightarrow {}^A\text{X} + \alpha$; (ii) ${}^{22}_{11}\text{Na} \rightarrow {}^A\text{X} + e^+ + \text{neutrino}$. X may be identified by either its atomic number or name. [6 marks]
- (d) The primary coil of an ideal transformer has 600 turns and the secondary coil has 200 turns. If the current in the primary coil is 13 A when 750 V is applied to it, what is (i) the voltage (ii) the current in the secondary coil? [6 marks]
- (e) If atmospheric pressure is 1.013 bar, at what depth (in m) below the surface of water will you experience a pressure of twice this value? (Density of water = 1000 kg/m³.) [6 marks]

Useful information

The acceleration due to gravity is $g = 9.8 \text{ m/s}^2$.