

CORK INSTITUTE OF TECHNOLOGY
INSTITIUID TEICNEOLAIOCHTA CHORCAI

Semester 2 Examinations 2009/2010

Module Title: PHYSICS

Module Code: PHYS6012

School: SCIENCE

Programme Title:

Bachelor of Science in Applied Physics and Instrumentation, Year 1

Bachelor of Science in Applied Biosciences, Year 1

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

Bachelor of Science (Hons) in Nutrition & Health Science, Year 1

Programme Code: SPHYS_7_Y1

 SBIOS_7_Y1

 SINEN_8_Y1

 SNHSC_8_Y1

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

Duration: 2 Hours

Sitting: Summer 2010

Requirements for this examination: Log tables.

- 1 (a) A stone is fired directly upwards from a height of 80 m with an initial speed of 120 m/s.
- (i) What is the maximum height that it will reach?
 - (ii) How long will it take to reach maximum height?
 - (iii) What will be its speed when it passes the launch position on the way down?
 - (iv) What will be its speed when it hits the ground? [10 marks]
- (b) How is force related to momentum? What speed would a tennis ball of mass 55 g need to give the same momentum as a football of mass 0.62 kg with a speed of 25 m/s? Which would be easier to stop? [7 marks]
- (c) Explain briefly (i) why the space shuttle needs a heat shield on re-entering the atmosphere (ii) under what conditions a body reaches terminal velocity in free-fall. [4 marks]
- (d) A box of mass 35 kg rests on a floor. Calculate the force needed to just get it moving if the coefficient of friction between the box and the floor is 0.42. [4 marks]

- 2 (a) What is meant by the terms (i) *monochromatic* and (ii) *intensity* as applied to light? For Young's slits of separation d , show that the condition for constructive interference is

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

- (b) Light with a wavelength of 546 nm passes through two slits and forms an interference pattern on a screen 8.75 m away. If the linear distance from the central bright fringe to the second bright fringe on the screen is 10.32 cm, what is the separation of the slits? [7 marks]
- (c) The print-out from a laser printer is actually an array of tiny dots. If the pupil of your eye has a diameter of 4 mm when reading a page held at a distance of 25 cm, what is the minimum separation of adjacent dots that can be resolved? (Take $\lambda = 550 \text{ nm}$.) [7 marks]

- 3 (a) Give an account of environmental radioactivity. [13 marks]
- (b) What do the terms (i) *isotope* (ii) *activity* mean?

Flourine-18 ($^{18}_{9}\text{F}$) is used in PET scans. If a patient is to be subjected to an activity of $4 \times 10^8 \text{ Bq}$, how many grams of $^{18}_{9}\text{F}$ would be required? How long will it take for the activity to decrease to $6 \times 10^7 \text{ Bq}$? (The half-life of $^{18}_{9}\text{F}$ is 110 minutes. Avogadro's number is $N_A = 6 \times 10^{23} \text{ mol}^{-1}$.) [12 marks]

- 4 (a) State Faraday's law of electromagnetic induction and use it to derive an expression for the voltage generated by a coil of area A rotating in a magnetic field of flux density B . [8 marks]
- (b) A generator is designed to produce a maximum emf of 17 V when rotating with an angular speed of 3600 rpm. If each turn of the generator coil has an area of 0.016 m^2 and the magnetic field used has a magnitude of 0.05 T, how many turns of wire are needed in the coil? [8 marks]
- (c) A solenoid of length 75 cm has 500 turns and carries a current of 3.5 A. The space inside the solenoid is filled with a material of relative permeability 4. Calculate the magnetic flux density inside the solenoid and the percentage change in magnetic flux density when the filling material is removed. (Take $\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$.) [9 marks]
- 5 (a) Obtain an expression for the variation of pressure with height h in a fluid. [8 marks]
- (b) Gas of density 1.2 kg/m^3 enters a pipe of diameter 2.4 cm at a speed of 8.5 m/s. If the pipe narrows to 1.8 cm and the gas leaves at 11 m/s, what is its new density? [8 marks]
- (c) Give an account of surface tension and give two examples of its effects. [9 marks]

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

- (a) Sodium has two prominent yellow lines in its spectrum, at wavelengths of 589.0 and 589.6 nm. What will be the angular separation between these lines in *second* order with a diffraction grating of 650 lines/mm? [7 marks]
- (b) Write down the decay equation for each of the following:
- (i) alpha (α)-decay of Rn-220 ($^{220}_{86}\text{Rn}$);
 - (ii) artificial β -decay (i.e., positron decay) of Cr-49 ($^{49}_{24}\text{Cr}$);
 - (iii) electron capture in Ca-41 ($^{41}_{20}\text{Ca}$).
- (The atomic number will suffice to identify the daughter nucleus. For electron capture, the secondary decay is *not* required.) [6 marks]
- (c) Water falls over a dam of height 70 m. What is the kinetic energy of 5 kg of water at the bottom of the dam? (Assume that it falls from rest.) If 40 % is converted to electrical energy in 2 seconds, what power does this generate? [6 marks]
- (d) A step-up transformer has 25 turns on the primary coil and 750 turns on the secondary coil. If this transformer is to produce an output voltage of 4800 V with a 12 mA current, what input current and voltage are needed? [6 marks]
- (e) 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. [6 marks]

Useful information

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