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

$$d \sin\theta = m\lambda \quad (m = 0,1,2,\ldots)$$ [11 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 λ = 550 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 ($^{18}_{9}F$) is used in PET scans. If a patient is to be subjected to an activity of 4×10^8 Bq, how many grams of $^{18}_{9}F$ would be required? How long will it take for the activity to decrease to 6×10^7 Bq? (The half-life of $^{18}_{9}F$ 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 $\mu_0 = 4\pi \times 10^{-7}$.) [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 $\mathrm{kg/m^3}$ 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 ($^{220}_{86}\mathrm{Rn}$);

(ii) artificial β-decay (i.e., positron decay) of Cr-49 ($^{49}_{24}\mathrm{Cr}$);

(iii) electron capture in Ca-41($^{41}_{20}\mathrm{Ca}$).

(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 $g = 9.8\ \mathrm{m/s^2}$.