

**CORK INSTITUTE OF TECHNOLOGY
INSTITIUID TEICNEOLAIOCHTA CHORCAI**

Semester 2 Examinations 2012/2013

Module Title: FUNDAMENTAL PHYSICS

Module Code: PHYS6042

School: Science & Informatics

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
Higher Certificate in Industrial Measurement and Control, Year 1

Programme Code: SESST_8_Y1
 SINEN_8_Y1
 SPHYS_7_Y1
 SIMCT_6_Y1

External Examiner(s): Dr S. Daly, Mr W. Power

Internal Examiner(s): Ms E Baldwin, Ms C. Devaney

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

Duration: 2 Hours

Sitting: Summer 2013

Requirements for this examination: Log tables.

- 1 (a) Explain what is meant by (i) *torque* and (ii) *moment of inertia*. [4 marks]
- The flywheel of an engine has a moment of inertia of 2.5 kgm^2 about its rotation axis. What constant torque is required to bring it to an angular speed of 4000 rpm in 8 s starting from rest? [8 marks]
- (b) (i) State the law of conservation of momentum. [2 marks]
- (ii) Define coefficient of friction. [2 marks]
- (iii) A 5 g bullet is fired horizontally into a 1.2 kg wooden block at rest on a horizontal surface. The coefficient of friction between the block and the surface is 0.2. The bullet remains in the block which slides 0.23 m before coming to rest.
- Calculate (i) the deceleration of the block,
(ii) the speed of the bullet and block just after impact
(iii) the speed of the bullet before it hits the block. [9 marks]
- 2 (a) Explain what is meant by (i) *coherent* and (ii) *monochromatic* [4 marks]
- (b) (i) Describe, with the aid of sketches what happens the interference pattern if we go from two slits to three to a very large number without altering the slit separation. Hence explain why a diffraction grating is more useful than Young's slits. [6 marks]
- (ii) Young's double slits experiment is performed with light of wavelength 502 nm. Fringes are observed on a screen 1.2 m from the double slit. If the distance from the central bright fringe to the tenth fringe is 5.3 mm, calculate the slit separation. [5 marks]
- (c) State the *Rayleigh criterion* and explain its relevance to the resolution of a telescope. [5 marks]
- An astronaut in the space shuttle can just resolve two point sources on earth that are 65m apart. What is his altitude above earth if the diameter of the pupil of his eye is 4 mm? Assume $\lambda = 550 \text{ nm}$. [5 marks]
- 3 (a) Describe the circumstances in which nuclei decay by (i) *alpha*, (ii) *positron* and (iii) *beta* emission. [10 marks]
- (b) What do the terms (i) *atomic mass number*, (ii) *half life* mean?
- Palladium-103 $^{103}_{46}\text{Pd}$ has a half-life of 17 days and is used in radiation therapy. Calculate the activity of 250 mg of it. What will be the activity after 68 days? (Avogadro's number is $N_A = 6 \times 10^{23} \text{ mol}^{-1}$.) [15 marks]

- 4 (a) Describe how an *ac generator* works, referring to Faraday's law of induction in your answer. What factors determine the size of the induced voltage? [9 marks]
- (b) A rectangular coil of 80 turns each of size 25 cm x 40 cm is located in a magnetic field of 1.1 T. The field is orientated at an angle of 53° with respect to the normal to the plane of the coil.
- (i) Calculate the magnetic flux through the coil.
- (ii) If the coil is rotated to a position where the plane of the coil is perpendicular to the magnetic field in a time of 0.06s, what emf is generated? [8 marks]
- (c) A 960 W coffee maker is designed to operate on 220 V. How can it be used with a 110V supply? Calculate the current drawn from the 110 V supply. [8 marks]

5 **Answer any five of the following parts:**

- (a) Write down the decay equations for each of the following:
- (i) Positron decay (β^+) decay of ${}_{14}^{27}\text{Si}$
- (ii) alpha decay of ${}_{88}^{217}\text{Ra}$ [5 marks]
- (b) What energy is used by a 100 W light bulb in 1 hour? At what speed will a 70 kg person need to run in order to have the same amount of energy? [5 marks]
- (c) Show that, for Young's slits, the condition for constructive interference is that
- $$m\lambda = d \sin \theta \quad (m = 0, 1, 2, \dots)$$
- [5 marks]
- (d) A straight horizontal rod of mass 50 g and length 0.5 m is placed in a uniform horizontal field of 0.2 T perpendicular to the wire. Calculate the current in the wire if the force acting on it just balances its weight. [5marks]
- (e) The height of the leaning tower of Pisa is 54.6 m. How long will it take a body to fall to the ground from the top of the tower? [5 marks]
- (f) For a diffraction grating with 600 lines/mm, find the angular position of the second order red line ($\lambda = 644 \text{ nm}$) in the cadmium spectrum. [5 marks]
- (g) Sketch the magnetic field surrounding a solenoid. What factors determine the magnetic flux density at the centre of the solenoid? [5 marks]

Useful information

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