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GX 906

Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

Semester II Examinations, 2002/2003

Exam Code(s) 1BS1, 1BO1, 1CS1, 1EL1, 1ER1, 1EV1, 1PT1

Exam(s) 1st Science

Module Codes EP101

Module(s) Experimental Physics

Paper No. _____
Repeat Paper _____ Special Paper _____

External Examiner(s) Prof. E.T. Kennedy
Internal Examiner(s) Prof. S.G. Jennings

Instructions: Answer Question 1 (30 marks) and FOUR questions from the remainder (10 marks each). The total marks for the paper are 70.
Use a separate answer book for each section

Duration THREE Hours
No. of Answer Books _____

Requirements:
Handout _____
Statistical Tables _____
Graph Paper _____
Log Graph Paper _____

No. of Pages _____

Department Experimental Physics

Q.1 Answer all parts (each part carries 1½ marks).

(a) Write down the units for the following quantities : acceleration, specific heat capacity, Young's modulus.

(b) A projectile is launched vertically upwards with an initial speed of 30 ms^{-1}. Calculate its velocity when it is 20 m above the ground and the time taken to reach its highest point.

(c) A 3.51 kg rifle fires a 9.72 g bullet with a velocity of 891 ms^{-1}. Calculate the recoil velocity of the rifle.

(d) A 20 kg object is hauled, at constant velocity a distance 10 m up a frictionless slope inclined at 30^{O} to the horizontal. Calculate the work done on the object.

(e) A compact disc is 12 cm in diameter and rotates at 400 revolutions per minute. Calculate the linear velocity of a point on the rim.

(f) A body floats in water with 25% of its volume above the level of the water. What is the relative density of the material in the body?

(g) The temperature of 1 kg of water in an electric kettle is raised from 20 °C to boiling point in 3 minutes. Calculate the rate at which heat energy is supplied by the heating element.

(h) Calculate the wavelength in air at (15 °C) of a sound wave with frequency of 600 Hz.

(i) An organ pipe which is 0.5 m long is open at one end and closed at the other. Calculate the wavelength of the sound emitted from the fundamental standing wave in the pipe.

(j) Calculate the electrostatic force of attraction between a proton and an electron which are separated by a distance of 10 nm.

(k) Calculate the energy stored in a 5.0 μF capacitor when it is charged to a potential difference of 2.0 V.

(l) During a certain electrical storm a flash of lightning was seen 5 s before the clap of thunder was heard. Calculate how far the lightning was from the observer.

(m) Calculate the resistance of a piece of nichrome wire which has a length of 3.0 m and a cross-sectional area of 1.5 mm^2.

(n) Calculate the time taken for a radio wave to travel a distance of 150 km.

(o) A light source radiates 5.00 W of light power uniformly in all directions. What is the intensity of illumination produced 10.0 m from the source?

(p) A beam of polarized light is incident on an ideal polarizer. What percentage of the incident light intensity is transmitted if the angle between the plane of polarization of the light and the transmission axis of the polarizer is 30 degrees?

(q) An object is placed 20 cm in front of a concave mirror that has a radius of curvature of 50 cm. What type of image is formed? Where exactly is the image located?

(r) Calculate the cutoff wavelength in an x-ray tube with an accelerating voltage of 20.0 kV.

(s) How much energy is generated if 1.00 mg of matter is converted totally to energy?

(t) Calculate the deBroglie wavelength of an electron that has a kinetic energy of 100 eV.

Q.2 Derive an expression for the acceleration of a body moving in a circular path with uniform speed. State Newton's Law of Gravitation. [3 marks, 1 mark]

Use these two results to derive an expression for the period of orbital motion of a satellite moving around a large mass M in a circular orbit of radius R. [3 marks]

Using the constants supplied at the end of the examination paper, calculate the distance (from the centre of the earth) at which satellites involved in Global Positioning Systems are located, if their orbital period is 12 hours. [3 marks]

Q.3. State clearly the Universal Gas Law for ideal gases, explaining all the terms used. Indicate briefly the assumptions used in deriving this relationship. [3 marks]

Describe an experiment to measure the variation with temperature of the pressure (at constant volume) of a sample of gas and show how this leads to the Kelvin scale of temperature [3 marks]

A bubble of oxygen gas, with a volume of 1 cm^3, escapes from a diver's cylinder at a point 75 m below the surface of a lake where the temperature is 5 °C. Calculate the <u>total</u> pressure acting on the bubble at this depth. [1 mark]

The bubble rises slowly to a point just below the surface, where the water temperature is 15 °C. Assuming that the temperature of the gas is equal to that of the surrounding water, calculate the volume of the bubble when it reaches the surface. Approximately how many gas molecules are contained in this bubble ? [3 marks]

Q.4 State Ohm's Law and Kirchhoff's two circuit rules for the analysis of electrical circuits, carefully explaining the terms used. [2 marks]
Derive an expression for the equivalent resistance of three resistors R1, R2, and R3 connected in series. [2 marks]
What is the total current drawn by the battery in the circuit shown? [2 marks]
Calculate also the voltage across the 1 Ω resistor [2 marks]
and the power dissipated by the 4 Ω resistor. [2 marks]

Q.5. Write down an expression for Faraday's Law of Electromagnetic Induction and also state Lenz's Law for the direction of the induced current. [2 marks]

Give a verbal explanation of how an emf is produced between the ends of a wire which is moving so as to intersect magnetic field lines. [2 marks]

A rectangular coil [20 cm x 30 cm] having 100 turns is rotated at 1200 revolutions per minute in a magnetic field of 0.5 T. Write down the expression for the emf produced and calculate the peak voltage produced during a revolution. Also sketch the voltage waveform produced and show its period. [5 marks]

On the same sketch show the voltage waveform produced if the angular velocity is doubled. [1 mark]

Q.6 Explain clearly what are meant by the terms diffraction and interference. [3 marks]

In a Young's slits experiment, two slits separated by a distance d are illuminated by light of wavelength λ, producing an interference pattern on a distant screen beyond the slits. Show that maxima in the interference pattern occur at angles θ, given by

$$m\lambda = d\sin\theta$$

where m is an integer value. [4 marks]

Two slits separated by a distance 1.20 mm are illuminated by light of and interference fringes are produced on a screen 5.40 m from the slits. Calculate the wavelength of the light if bright fringes on the screen are separated by 2.30 mm. [3 marks]

Q.7 State clearly what are meant by alpha decay, beta decay, and gamma decay, of a nucleus. In each case, show how the atomic number and atomic mass number of the decaying nucleus changes. [4 marks]

A sample contains N_0 radioactive atoms at time zero. Derive an expression for N, the number of radioactive atoms remaining in the sample a time t later. Using this expression, derive a relationship between the half-life and the decay constant. [4 marks]

One gram of radium-226 contains 2.66×10^{21} atoms and has a half-life of 1.60×10^{3} years. Calculate the activity of one gram of radium-226. (Take 1 year = 365.25 days.) [2 marks]

Q.8. Write on **ONE** of the following topics: [10 marks]

(a) Explain the importance of conduction, convection, and radiation in home heating and describe how energy usage can be minimised by good design and appropriate selection of construction materials.

(b) The Physics of the Sound of Music.

(c) Sources of Renewable Energy