GX G0907

Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

Semester II Examinations, 2002/2003

Exam Code(s)	EP103
Exam(s)	1st Engineering and I.T.
Module Code(s)	1BE1, 1BG1, 1BI1, 1BJ1, 1BM1, 1BN1, 1BP1, 1BV1, 1EG1, 1IF1
Module(s)	Experimental Physics
Paper No.	1
Repeat Paper	_____ Special Paper _____
External Examiner(s)	Professor E. Kennedy
Internal Examiner(s)	Professor S. G. Jennings

Instructions: Answer all of 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 Question 1.

Duration	3 hrs.
No. of Answer Books	1
Requirements:	
Handout	
MCQ	
Statistical Tables	
Graph Paper	
Log Graph Paper	
Other Material	
No. of Pages	
Department(s)	Experimental Physics

Q1. Answer all parts (each part carries 1½ marks)

(a) Draw a free body diagram showing the external forces (together with their magnitudes) that act on a stationary 200g mass which sits on the horizontal surface of a table (near the surface of the earth).

(b) What is the change in gravitational potential energy when a 4 kg mass is moved from a height of 6m above the ground to a concrete plinth 1m above the ground?

(c) A car travelling at speed along a horizontal stretch of road applies its brakes in order to come to a stop. Given that the coefficient of static friction between the car tyres and the road is 0.75 calculate the maximum deceleration that can be attained without the car skidding.

(d) Calculate the magnitude of the gravitational force between an electron and a proton positioned 10^{-10} m apart, and detail the direction of the force.

(e) A 20g mass travels in a circular path of radius 50cm with a uniform speed due to a centripetal force of magnitude 3.6N. What is the translational kinetic energy of the mass?

(f) A car of mass 1700 kg travelling in a straight line with a velocity of $22ms^{-1}$ collides head on with a concrete bridge support. The collision results in it being brought to a halt in a time of 0.9 seconds. Calculated the average force that acts on the car during the collision.

(g) An electron experiences an electrostatic force of magnitude $7.5x10^{-19}N$. Calculate the magnitude of the corresponding electric field and state the direction of the electric field vector relative to that of the electrostatic force.

(h) A capacitor with a potential difference of 10V across it holds a charge on each plate of 0.2μC. What is the electrical energy stored in the capacitor?

(i) Calculate how many electrons pass a point in a circuit in 1 minute when the electric current passing the location is 35mA.

(j) Calculate the change in electric potential energy for a charge of +6μC that is moved through an electric potential difference of +1V.

(k) A 10 turn circular coil of copper wire with a radius of 1cm has a uniform magnetic field of 50mT passing through it at right angles to the plane of the coil. Calculate the induced emf in the coil if the strength of the magnetic field is decreased uniformly to zero over a time interval of 10ms.

(l) Draw a clearly labelled ray diagram to locate the image of an object placed a distance 2f in front of a concave mirror (where f = focal length of the mirror in question).

(m) A converging lens of focal length = 20cm is used to form an image of a distant tree on a sheet of paper. Determine the position of the image relative to the lens if the tree is assumed to be located at infinity relative to the lens.

(n) Viewed from above the surface of the water, a swimming pool appears to have a depth of 1.5 meters. Given that the refractive index of water is 1.33 calculate the real depth of the pool.

(o) The wavelength of an electromagnetic wave is determined to be 600nm. What is the frequency of the wave?

(p) The Bohr energies of the ground state and first excited state of a hydrogen atom are –13.6eV and –3.4 eV respectively. Calculate the wavelength of the photon emitted in an electronic transition between the excited state and the ground state.

(q) An alpha particle enters a region of uniform electric field = 1000V/m. Calculate the magnitude of the electrostatic force on the particle and determine the direction of the force relative to that of the electric field vector.

(r) The work function of a metal is 2.4eV. What is the largest wavelength of light that will cause photoelectrons to be ejected from the surface of the metal?

(s) After 15.81 years the number of radioactive nuclei of a particular isotope deceases to one eight of the number initially present. Calculate the half-life of the substance.

(t) A radioisotope decays by β^- particle emission. Relate the mass number and atomic number of the daughter particle produced by the decay to that of the parent nucleus.

Q.2 Define velocity and acceleration in relation to particle motion and write the associated SI units in each case. [2 marks]

A stone is thrown vertically upward from the edge of a 24m high building with initial velocity 2.7 m/s. The stone just misses the building on the way down. Neglecting air resistance:

(a) Calculate how long after release it takes for the stone to reach its maximum height. [2 marks]

(b) Determine the time of flight of the stone (time taken to reach the ground). [3 marks]

(c) If instead, the stone was dropped initially with zero velocity what would the speed of the stone be just before it hits the ground and how long after release would it take to hit the ground. [3 marks]

Q.3 State the conservation laws that apply in the case of elastic and perfectly inelastic collisions between particles. [2 marks]
Apply the laws to the case of two particles making (i) an elastic (ii) an inelastic collision. [2 marks]

A 1.0 kg object travelling at 1.0 m/s collides head on with a 4.0 kg object that is initially at rest.

(a) Calculate the linear momentum of the 1kg and 4.0 kg masses before the impact. [2 marks]

(b) Find the velocity of each object after impact if the collision is elastic. [4 marks]

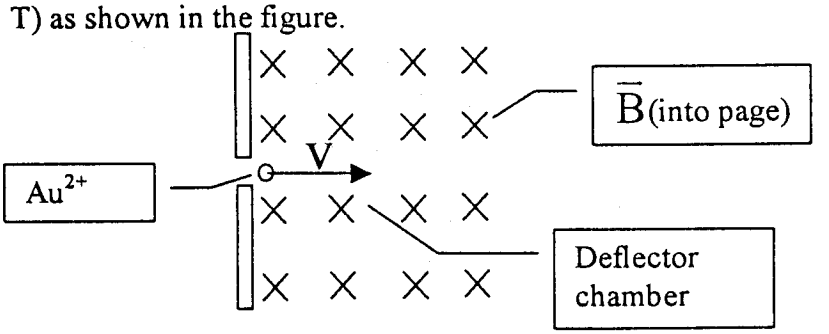
Q.4 Define the electric field and show the relationship between the field and the Coloumb force on a charge (explain all the terms used). [2 marks]

Two positive charges $q_1 = +20\mu C$ and $q_2 = +5\mu C$ are separated in vacuum by a distance of 1m. Calculate the location, P, on the line joining the two charges where the net electric field is zero. [4 marks]

If the charge q_2 in the above system is replaced by a charge $q_3 = +20\mu C$, calculate the electrostatic force on a charge of $-2\mu C$ located on the line between the charges at a point 0.4m from q_3. [4 marks]

Q.5 State the Lorentz force law relating the force on a charged particle moving in a magnetic field and explain the terms involved. [2 marks]

In a mass spectrometer an ion source produces doubly ionised gold ions, Au^{2+} (mass of ion = 3.27×10^{-25}kg). The ions are accelerated from rest through a potential difference of 1.2kV before entering a region of uniform magnetic field (B= 0.8 T) as shown in the figure.



With the aid of a clearly labelled diagram indicate the direction of the force on an ion immediately after it enters the B field region. [2 marks]

Determine the translational kinetic energy and speed of the ions as they enter the deflector chamber. [3 marks]
If the accelerating potential is altered so that the ions enter the deflector chamber with a velocity of 4×10^4 ms^{-1}, calculate the radius of the circular path that the ions follow in the region. [3 marks]

Q.6 State Snell's law describing the refraction of light and illustrate the key terms involved with the aid of a clearly labelled diagram. [2 marks]

Explain what is meant by Total Internal Reflection and derive an expression for the critical angle. [2 marks]

A ray of light travels through a block of glass ($n_g = 1.5$) and strikes the plane surface of the glass interface at an angle of 45° to the normal. Calculate the critical angle and determine if the ray will undergo total internal reflection at the interface under the following conditions:

(a) the other side of the glass interface is filled with water with a refractive index of 1.33. [2 marks]

(b) the other side of the glass interface is air with a refractive index of 1.[2 marks]

Calculate the angle of refraction or reflection as appropriate and sketch the path of the incident light ray and the light ray after it intercepts the glass interface in both the cases a) and b) above. [2 marks]

Q.7 With the aid of a clearly labelled diagram describe the basic geometry of the Young's double slit experiment and derive the expression to locate the interference fringes for successive orders in the viewing plane. [4 marks]

Red light from a laser source ($\lambda = 632$nm) is used to illuminate the slits in a Young's experiment with a slit separation of 0.125mm. The resulting fringes are viewed on a screen 2.6m from the slits. Calculate the distance between the central fringe and the 4^{th} order bright fringe. [4 marks]

When illuminated by a second source the 4^{th} order bright fringe of the new pattern has an angular separation of 0.93 degrees relative to the central bright fringe. What is the wavelength of the second source? [2 marks]

Q.8 With the aid of a clearly labelled diagram(s) explain the basic operation of an x-ray tube and outline in brief the two x-ray emission processes that may take place within the tube. [4 marks]

Electrons are accelerated through an electric potential difference of 48 keV before hitting a molybdenum target. Calculate the wavelength of the highest energy x-rays produced by the Bremsstrahlung emission process. [2 marks]

The x-ray source discussed produces K_β and K_α emissions at wavelengths of 0.063 and 0.07nm, respectively. Show the effect of increasing the accelerating voltage from 48 keV to 65 keV on the x-ray emission spectrum by sketching the x-ray intensity as a function of wavelength before and after the increase. Highlight the key features of the spectrum including the value of the cut-off wavelengths in the Bremsstrahlung emission in both cases. [4 marks]