

SPRING EXAMINATION 1999

FIRST YEAR EXAMINATION IN MEDICINE

Experimental Physics

Dr. J.M. Woolsey
Prof. P.W. Walton

Time allowed : Three hours.

Answer question 1 (35 marks) and THREE questions from the remainder. The total marks for the paper are 70.

Use a separate answer book for Question 1.

Numerical values of the required physical constants and relevant data are given at the end of the paper.

Q.1 Answer all parts.

- (a) Convert 0.52 meters to millimeters.
Convert 458 milligrams to kilograms.
- (b) Which of the following quantities are vectors ? Acceleration, mass, electric field, temperature.
- (c) A car goes from rest to 75 m s^{-1} in 15 s, what is the acceleration ?
- (d) If an object is projected upwards with a velocity of 80 m s^{-1} , what is the maximum height attained ?
- (e) A person walks 3 km due east and then 4 km due north. What is the magnitude and direction of his displacement ?
- (f) What is the weight of a mass of 100 grams ?
- (g) If a shaft is rotating at 30 revs per sec., what is its angular velocity ?
- (h) What is the force between two spherical objects of masses 100 kg and 200 kg if their centres are separated by a distance of 150 cm ?
- (i) What is the work done against gravity in raising an object of mass 120 kg through a height of 5 m.
- (j) If the speed of a car doubles, by what factor does its kinetic energy increase ?
- (k) Find the average power to accelerate a 1000 kg car from rest to a speed of 40 m s^{-1} in 20 s.
- (l) If electricity costs 8 p/kwh how much does it cost to run a 4 kW electric fire for 2 hrs.?

- (m) If a gun of mass 2 kg shoots a 20 g bullet with a muzzle velocity of 150 m s^{-1} , what is the recoil velocity of the gun ?
- (n) In elasticity what do you mean by stress and strain ?
- (o) Convert body temperature of 98.6°F to Celsius degrees and to degrees absolute.
- (p) What is atmospheric pressure in Pascals if it supports a 76 cm column of mercury in a Fortin barometer.
- (q) If the temperature of a fixed volume of gas increases from 5°C to 95°C , by what factor does the pressure change ?
- (r) By how much does a 1200 m steel bridge expand if the temperature changes from -5°C to 30°C ?
- (s) If a ball of radius 5 cm is submerged in water what is the upthrust it experiences ?
- (t) The density of blood is 1060 kg m^{-3} and the blood pressure of a standing person at the heart level is 13.3 kPa. What is the blood pressure in the foot at a vertical height of 1.3 m below the heart ?
- (u) What is the force on an electron in an electric field of 10 V m^{-1} ?
- (v) Sketch the electric field due to a dipole.
- (w) How much energy is stored in a $100 \mu\text{F}$ capacitor charged to a potential of 50 volts ?
- (x) If a 6 V battery has an internal resistance of 2Ω and is delivering a current of 1 A, what is the terminal voltage ?
- (y) What is the wavelength of a radio station operating at a frequency of 98.6 MHz ?
- (z) Using a ray diagram show where the image is formed in a concave mirror if the object is outside the radius of curvature.
- (A) How many neutrons are there in ${}_{92}^{238}\text{U}$?
- (B) What is the energy of a photon of green light of wavelength $\lambda = 0.5 \mu\text{m}$?
- (C) What is the speed of light in glass if the refractive index is 1.5 ?
- (D) Technetium-99 m has a half life of 6 hours. What fraction remains after one day ?

Q.2 State the conditions necessary for equilibrium of a rigid body.

Explain how you would determine the position of the centre of gravity of a person.

Draw a diagram of the system for traction of a fractured femur known as Russell's traction .
Prove that the net force of traction is along the direction of the femur.

Q.3 Define what is meant by the refractive index of a medium.

Explain the phenomena of total internal reflection deriving the equation relating the critical angle and the refractive indices. Describe in detail a medical application of total internal reflection.

Q.4 Draw a set of graphs showing how the spectrum of black body radiation changes with the temperature of the radiating object.

Explain the principles involved in the greenhouse effect. Mention two greenhouse gases.

What is thermography and what are some applications for it, including medical examples.

Explain the meaning of the terms used in Stefan's Equation:

$$H = e \sigma A T^4$$

Q.5 Outline, using a diagram, the operation of moving coil galvanometer.

A basic galvanometer has a coil resistance of 100Ω and a full scale deflection of 1 mA. Show how the galvanometer can be modified to (a) make an ammeter of full scale deflection 20 A and (b) a voltmeter to have a full scale deflection of 100 V.

Q.6 Write a essay on the subject of electrical safety. Include in your answer a description of the effects of different currents in the body, of the earth leakage circuit breaker and of the importance of earthing. Also include a description of defibrillation.

Q.7 Describe the operation of an old and a modern type of instrument used in nuclear medicine imaging.

List some properties of Technetium-99 m that make it suitable for use in NM imaging. Mention some medical studies performed with these techniques.

Q.8 Describe using a diagram the operation of a radiographic (X-ray) imaging system. Include a description of the X-Ray tube, the filter, the fluorescent screens, and the grid.

Draw a diagram of a modern fluoroscopy system.