Queen Mary
University of London

# BSc/MSci EXAMINATION

PHY-106 Principles of Fields and Waves

Time Allowed: 2 hours 15 minutes

Date: 8th May 2007

Time: 14:30

**Section A: Answer ALL the questions. An indicative marking scheme is shown in square brackets [ ] after each part of a question.**

**Total marks for this section is 24.**

**Section B: Answer THREE out of the four questions only. Each question is worth 12 marks. An indicative marking scheme is shown in square brackets [ ] after each part of a question.**

**Total marks for this section is 36.**

**COMPLETE ALL ROUGH WORKINGS IN THE ANSWER BOOK AND CROSS THROUGH ANY WORK WHICH IS NOT TO BE ASSESSED.**

**You may use a Numeric electronic calculator during this examination.**

**Data**

| | | | |
|---|---|---|---|
| universal gravitational constant | $G$ | $6.7 \times 10^{-11}$ | $Nm^2kg^{-2}$ |
| Mass of Earth | $M$ | $6 \times 10^{24}$ | kg |
| permittivity of free space | $\varepsilon_o$ | $8.85 \times 10^{-12}$ | $F\,m^{-1}$ |

**DO NOT TURN TO THE FIRST PAGE OF THE QUESTION PAPER UNTIL INSTRUCTED TO DO SO BY THE INVIGILATOR.**

**Section A - Answer all questions in this section**

A1

a) State Newton's Universal Law of Gravitation in words. [1]

b) If the gravitational potential energy per unit mass ($U$) of a body on the surface of the Earth is given by the expression $U = -\frac{GM}{R}$, where $M$ and $R$ are the mass and radius of the Earth respectively, calculate the minimum velocity which a rocket must achieve if it is to escape the Earth's gravitational field. [3]

A2

a) State what is meant by the phrase "electric field strength at a point in an electric field" and give the units. [2]

b) Calculate the electric field strength at a point which is 0.2 m from a charge of $+5\ \mu C$. [2]

A3

The diagram below shows two conductors carrying the same current in the same direction into the paper.

a) Copy the diagram and draw a number of magnetic lines of force to illustrate the shape of the magnetic field. [2]

b) Show the direction of the force acting on each conductor. [1]

c) State the rule that relates the direction of the lines of magnetic force to the direction of the current flowing in the conductor. [1]

A4

A string is fixed at both ends is made to vibrate in the fundamental mode by plucking the string in the middle. Draw fully labelled diagrams to illustrate the following.

a) The fundamental and the first harmonic for the vibrating string. [2]

b) Mark the positions of all nodes and antinodes. [1]

c) What action must be taken when plucking the string to produce the first harmonic mode.. [1]

A5

a) State what is meant by the term diffraction. [1]

Monochromatic light is passed through a narrow slit and the resulting diffraction pattern observed on a screen.

b) Sketch and label the variation in intensity seen on the screen. [3

Please turn over.

A6

a) Sketch part of the electro-magnetic spectrum to show the relationship, in terms of wavelength, of the ultraviolet, infra-red, micro-wave and radio radiations to each other and to the visible part of the electro-magnetic spectrum [2]

b) Choose one of the radiations listed above and describe the principal characteristic and one mode of detection. [2]

**Section B - Choose three out of the four questions ONLY in this section.**

B1

a) State, in words, Faraday's law of electromagnetic induction. [2]

b) Write the defining equation and explain the significance of the minus sign. [2]

The sound system in a student union has a record turntable of diameter 0.28 m which rotates at $33^1/_3$ rpm (revolutions per minute) when in use. The value of the horizontal component of the Earth's magnetic field is known to be $2\times10^{-5}$ T and the angle of dip is $70^\circ$.

c) Calculate the magnetic flux linked with the turntable. [5]

d) Calculate the value of the emf induced between the spindle and the edge of the turntable. [3]

B2

a) State what is meant by simple harmonic motion. [2]

A mass of 0.10 kg hangs from a long spring. When pulled down 0.1 m below its equilibrium position A and released, it vibrates with simple harmonic motion with a period of 2.0 s.

b) What is the velocity as it passes through *A* ?. [2]

c) What is the acceleration when the mass is 5 cm above *A* ?. [3]

d) What is the maximum value of the kinetic energy of the mass, and where does this maximum value occur ?. [3]

e) What is the total energy of the system and state how it will vary with time [2]

Please turn over.

B3 In an experiment to measure the speed of sound, a student used a resonance tube of length 0.4 m, closed at one end, and a signal generator driving a small speaker as the source of sound at the other end. The signal generator had an available range of 200Hz to 1200 Hz

a) Draw a diagram to show how the equipment would be arranged and describe how resonance would be detected. [2]

b) Describe the steps necessary to obtain data. [2]

c) Calculate all the frequencies at which resonance would be found given that the speed of sound in the laboratory was $3.44 \times 10^2 \text{ ms}^{-1}$. [7]

d) What assumption have you made in your calculations. [1]

B4 In an interference experiment, the equation $w = \frac{\lambda D}{a}$ relates the fringe width $w$, the wavelength $\lambda$ , the slit –screen separation $D$ and the distance between the slits $a$

a) Describe, with the aid of a fully labelled diagram, how you would use a laser, a double slit and a screen to determine the wavelength of the laser. List any other equipment needed. [5]

b) In an experiment, it was found that the spacing of 16 fringes was 0.2 m. The slits were 0.25 mm apart and the screen was 5 m away from the laser. Calculate the wavelength of the laser. [4]

c) The intensity of the bright fringes is not uniform and seems to rise and fall across the screen, the brightest being at the centre of the pattern. Explain, with the use of a labelled diagram, the cause of this modulation. [3]

End of Examination Paper
Mr J. Murphy