Queen Mary
University of London

# BSc/MSci EXAMINATION

SEF - 006 Physics (Fields and Waves)
PHY - 106 Principles of Fields and Waves

Time Allowed: 2 hours 15 minutes

Date: 26th May 2006

Time: 10:00

**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.**

**You may use an electronic calculator during this examination.**

**Data**

| | | | |
|---|---|---|---|
| Gravitational constant | G | $6.7 \times 10^{-11}$ | $Nm^2kg^{-2}$ |
| Acceleration of free fall | g | 9.8 | $m\,s^{-2}$ |
| Permeability of free space | $\mu_o$ | $4\pi \times 10^{-7}$ | $Hm^{-1}$ |
| Speed of sound in air | v | 340 | $ms^{-1}$ |
| Permittivity of free space | $\varepsilon_o$ | $8.85 \times 10^{-12}$ | $F\,m^{-1}$ |
| Radius of the Earth | $R_E$ | $6.4 \times 10^3$ | km |

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

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## Section A - Answer all questions in this section

A1) (a) State Faraday's law of induction and explain the significance of the negative sign. [2]

(b) An aircraft with a wing span of 40 m is flying due north, on a horizontal track, with a velocity of 140 $ms^{-1}$ in a region where the vertical component of the earth's magnetic field is $2.0 \times 10^{-5}$ T. Calculate the emf induced between the wing tips of the aircraft. [2]

A2) The sketch below shows a bar magnet placed on the magnetic meridian with its N-pole pointing towards magnetic north.


Copy the diagram and sketch the magnetic field for the region surrounding the magnet. [2]

Your diagram should indicate the relative strength of the field for the region and the positions of any neutral points. [2]

A3) (a) State what is meant by "electric field strength at a point in an electric field". [1]

(b) Two horizontal metal plates are separated by 20 cm of air. The lower plate is connected to earth and the upper one is connected to the positive terminal of a 20 kV dc supply. Calculate

(i) Calculate the electric field strength at the centre of the plates and [2]

(ii) Sketch the plates and add some "lines of electric force" to illustrate the field between the plates. [1]

A4) Sound is described as a longitudinal wave, requiring a medium.

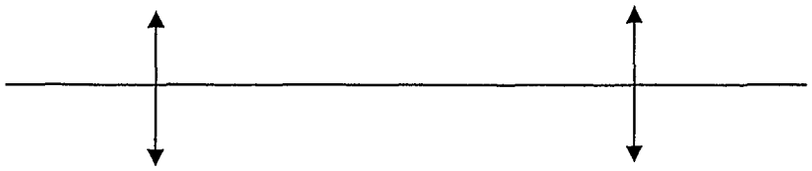
(a) Draw a fully labelled diagram to illustrate how the direction of energy transfer is related to the direction of the vibration in the medium. [2]

(b) A sound wave of frequency 1000 Hz is transmitted through a copper rod. If the speed of sound in copper is 3800 $ms^{-1}$, calculate the wavelength of the sound wave. [2]

**The examination continues on the next page**

A5) (a) Derive an expression for the magnifying power of a telescope in normal adjustment. [2]

The diagram below shows the arrangement of lenses in a refracting telescope



Objective lens (f = 1.0 m) Eye lens (f = 12.5 cm)

(b) Copy the diagram and draw three rays through the telescope when in normal adjustment. [1]

(c) Calculate the magnifying power [1]

A6) Sketch the em spectrum showing the positions of micro-waves, infra-red, ultra-violet, radio waves relative to the visible region. Explain why bodies at around room temperature readily absorb infra-red radiation. [4]

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

B1) (a) State Newton's Universal Law of Gravitation.
Write the law in equation form defining all terms. [2]

(b) If the acceleration of free fall, $g_m$, at the surface of the moon is 1.7 $ms^{-2}$

(c) To what height would a signal rocket rise on the moon if an identical rocket would reach 200 m on earth.
You may ignore the effects of air resistance. [6]

B2) (a) Describe fully how a stationary wave differs from a plane progressive wave. Draw a diagram to show the positions of any nodes and antinodes for a closed pipe producing the fundamental frequency. [6]

(b) Define the terms node and antinode [2]

(c) Given that the distance between successive antinodes in a stationary wave is 20 cm, calculate the velocity of the wave if the frequency is 800 Hz. [4]

**The examination continues on the next page**

B3) (a) State the conditions necessary for a body to perform simple harmonic motion. [2]

(b) A 0.01 kg mass is suspended from a light spring of natural length 0.08 m and produces an extension of 10 mm. The mass is then pulled down a further 5 mm and released. Calculate

(i) the spring constant. [3]

(ii) the period of the motion. [3]

(iii) the velocity and kinetic energy of the mass as it passes through the centre of the motion. [4]

B4) (a) Describe the experimental arrangement for the production of interference fringes by Young's two-slit method Derive a relationship to calculate the fringe separation in terms of the slit-screen distance, the wavelength of the light and the distance between the two slits [6]

(b) In such an experiment, the fringe width for light of wavelength 550 nm was found to be 0.24 mm. The source was then replaced by one which produced a wavelength of 440 nm. Calculate

(i) the distance between the fringes for the new source and [4]

(ii) describe and explain what would be seen on the screen if ONE of the slits was covered up. [2]

**Mr J. Murphy**