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UNIVERSITY OF EXETER

PHYSICS

~~JANUARY 20XX MAY 20XX AUGUST 20XX~~

~~MODULE TITLE~~

Duration: TWO~~ HOURS AND THIRTY MINUTES~~

Answer question 1 and TWO other questions.

Maximum marks (100) are attained with complete answers to question 1 and two others. (Marks may be subject to scaling by the APAC.)

Use a single answer book for all questions (1 book).

Materials to be supplied:

Physical Constants sheet.

Approved calculators are permitted.

This is a 'closed note' examination.

1. Read <http://newton.ex.ac.uk/handbook/ExamProcedures.html> **Guidelines For Setting Exams** from which this template has been prepared. The implication of these is that, within a question, no attempt should be made to assign equal marks for equal difficulty. We should, however, be guided by the principle of equal marks for equal time spent by a good candidate in answering the question. Where appropriate, examiners should attempt to include a reasonable number of simple numerical calculations with a paper.

   Now set a question that meets the above specifications and answer the following:

   (a) Are approximately 40% of the marks for the question for relatively straight-forward material (*e.g.* basic concepts and definitions) and answerable by any student who has attained the essential learning outcomes (threshold level) and will they be answerable by all students who have done a reasonable amount of revision? **[13]**

   (b) Are the remaining marks for the question (approximately 50%) for material at an intermediate level. **[17]**

   (c) Are approximately 10% of the marks for the question for difficult material that only potential first-class students are expected to answer well? **[4]**

Turn Over

2 (i) The template has three styles, to be used as follows:

(a) **EXAM1** is for the main sections of the question; **[2]**

(b) **EXAM2** is for sequences or lists labeled (a), (b), (c), *etc.*; **[3]**

(c) **DISPLAY EQUATION** is for displayed equations. **[2]**

Use (i), (ii), (iii), *etc.* to label sections of the question **only** if these relate to different topics; principal sections do not need labeling if they all relate to the same overall topic – just use separate paragraphs. **[5]**

Use (a), (b), (c), *etc.* to label such things as a sequence of quantities to be calculated or a list of terms to be defined. Such lists should normally use EXAM2 format. **[6]**

Avoid asking several separate questions in the same paragraph with the marks given in one square bracket at the end, *e.g.* **[2, 3, 2]**. In such cases use a list labelled (a), (b), (c), normally in EXAM2 format, or give each question its own EXAM1 paragraph.

If character formatting is used to produce subscripts, superscripts, *etc*. ensure the size and offsets applied match the the equation editor settings.

(ii) Almost all symbols (whether Latin or Greek) should be typed in italics. The three main exceptions are mathematical functions (cos, ln, *etc.*), subscripts that relate to names or words (k_B, E_{ext}, *etc.*), and physical units (mA, kg, *etc.*). Vectors should be normally be typed in ***bold italic*** (without arrow or underline). Subscripts and superscripts should be 9-point size. Type 0 (*i.e.* zero), not o (*i.e.* the letter 'oh'), for superscript or subscript 'nought'. Put a space between quantity and unit, and between elements of a unit (*e.g.* 59 m s^{-1}, *not* 59ms^{-1}). Do not use a hyphen ('-') as a minus sign, the correct symbol ('–') is longer. Punctuate formulae and symbols as parts of the sentence that contains them. **[9]**

Turn Over

3. Define the **vector potential** and state how it is related to the magnetic flux through a loop. **[5]**

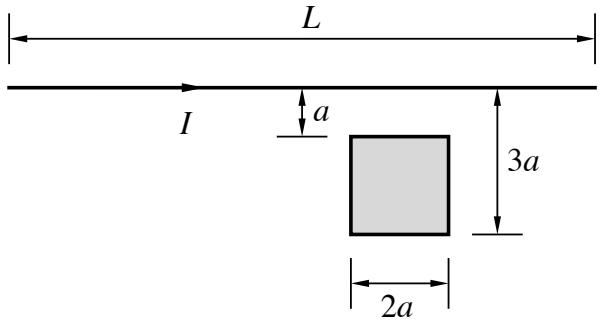
A long thin wire, length L, in free space carries a current I. Provided $L \gg r$ the magnitude of the vector potential $\boldsymbol{A}$ at a distance r from the midpoint of the wire on a line perpendicular to its axis is

$$|\boldsymbol{A}| = \frac{\mu_0 I}{2\pi} \ln(L/r).$$

(a) What is the direction of the vector $\boldsymbol{A}$? **[2]**

(b) Use the the vector potential to find an expression for the magnetic flux density $\boldsymbol{B}$ due to the wire. **[4]**

Hence find the flux through the square loop (which lies in the same plane as the wire) shown in the diagram. **[5]**



If the loop has a resistance $R = 19\,\Omega$ and the current I flowing in the straight wire increases at a rate of $3\,\mathrm{A\,s^{-1}}$ what current is induced in the loop if its area is 5 cm^2 ? Ignore the self-inductance of the loop, *i.e.* ignore the field due to induced currents circulating. Under what circumstances would you expect this to be a poor approximation? **[4]**

$$\left[\nabla \times \boldsymbol{F} = \left(\frac{1}{r}\frac{\partial F_z}{\partial \theta} - \frac{\partial F_\theta}{\partial z}\right)\hat{\boldsymbol{r}} + \left(\frac{\partial F_r}{\partial z} - \frac{\partial F_z}{\partial r}\right)\hat{\boldsymbol{\theta}} + \frac{1}{r}\left(\frac{\partial}{\partial r}(rF_\theta) - \frac{\partial F_r}{\partial \theta}\right)\hat{\boldsymbol{z}}\right]$$

END OF PAPER