Family Name (Please print in BLOCK LETTERS)	Given Name(s) as on student card	Student Number	Tutorial Group Code (F1C or F3C)

PHY132H1F
Test 2 —version 1
Tuesday, November 17, 2009
Duration: 80 minutes

PLEASE read carefully the following instructions.

Aids allowed: A non-programmable calculator without text storage. A single, hand-written aid-sheet prepared by the student, no larger than 8.5"x11", written on both sides.

- **Turn off** any communication device (phone, pager, PDA, iPod, etc.) you may have and place it far from where you are sitting.

- **DO NOT separate the sheets of your question paper.** Work lost or unattributable because of separated sheets will not receive any credit. You can, however, "carefully" tear off the blank page at the end, as it does not have to be handed in.

- Before starting, please **PRINT IN BLOCK LETTERS your name, student number, and tutorial group code** at the top of this page **and** on the answer sheet.

- Check that the test-version numbers under the shaded circle at the top right of the answer sheet and in the title of your test paper match. If they do not, call an invigilator; if they do, **do not write anything on or near the circles.**

Scanned Area of the Answer Sheet:

1. **Use a dark-black, soft-lead pencil or a black pen.**
2. Mark in your student number by shading the circles in the student number area.
3. Indicate your answer to a multiple-choice question by **thoroughly** filling the appropriate circle on the answer sheet and also by recording your answer on the test paper.
4. If you wish to modify an answer, erase your pencil mark thoroughly, or use dry tape white-out sparingly.
5. **Do not write anything else on the answer sheet.** Use the blank sheets at the end or the back of the question sheets for rough work.

The test consists of **8** multiple-choice questions, worth 2 points each, or altogether 16 points. The test also has a set of free-form questions worth 12 points, for which fully worked solutions are required. The total possible number of points is 28.

Multiple-choice questions:

- Please choose the best answer.
- Blank or incorrect answers are worth zero points.
- Multiple answers for the same question result in zero points for that question.

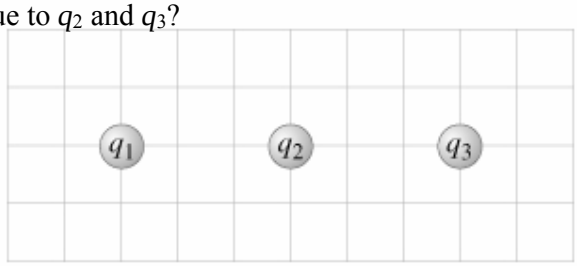
Free-form Questions: To be awarded maximum credit, you must provide fully worked solutions to all parts of the free-form questions. In addition to showing your work, please put your answer(s) for each part in the boxes provided. You can use the back-side of the sheets and the blank pages at the end for your rough work which will not be graded or taken into account.

When the invigilators declare the test ended, **stop any writing or filling of circles** on the answer sheet immediately. Please put your answer sheet **inside your test paper** and have the paper ready for an invigilator to pick up.

$\pi = 3.14159$

MULTIPLE CHOICE (16 points total)

1. In the diagram below, there are three point charges, all along the same line: q_1, q_2 and q_3. The distance between q_1 and q_2 is the same as that between q_2 and q_3. Consider the Coulomb force on q_1. Define positive force as toward the right, and negative force as toward the left. Of the following five combinations of possible electric charges, which will produce the greatest positive Coulomb force on q_1 due to q_2 and q_3?

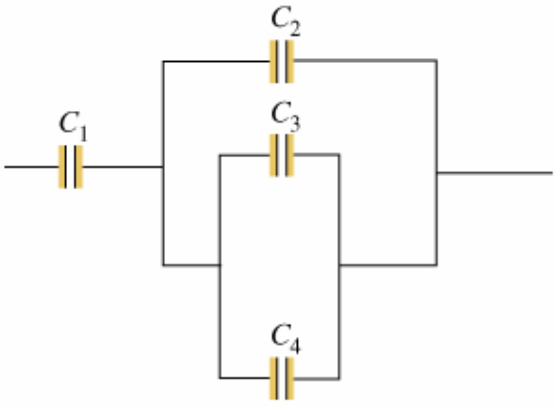


A. $q_1 = +1$ nC, $q_2 = -1$ nC, $q_3 = +1$ nC
B. $q_1 = +1$ nC, $q_2 = +1$ nC, $q_3 = -1$ nC
C. $q_1 = -1$ nC, $q_2 = -1$ nC, $q_3 = -1$ nC
D. $q_1 = +1$ nC, $q_2 = -1$ nC, $q_3 = -1$ nC
E. $q_1 = +1$ nC, $q_2 = +1$ nC, $q_3 = +1$ nC

2. A particular dipole consists of a positive charge at $x = 0.2$ m, $y = 0$ m and a negative charge at $x = -0.2$ m, $y = 0$ m. If the charges have magnitudes of 10^{-9} C each, what is the dipole moment?
A. -4×10^{-10} C m $\hat{x}$
B. -2×10^{-10} C m $\hat{x}$
C. $+2 \times 10^{-10}$ C m $\hat{x}$
D. $+2 \times 10^{-10}$ C m $\hat{y}$
E. $+4 \times 10^{-10}$ C m $\hat{x}$

3. A proton is released from rest at the positive plate of a parallel-plate capacitor. A vacuum separates the two plates. The proton crosses the capacitor, and just before it hits the negative plate, it has a final speed of 1.0×10^4 m/s. What will be the proton's final speed if the experiment is repeated with double the amount of charge on each capacitor plate?
A. 5.0×10^3 m/s
B. 1.0×10^4 m/s
C. 1.4×10^4 m/s
D. 2.0×10^4 m/s
E. 4.0×10^4 m/s

4. Consider the combination of capacitors shown in the diagram, where $C_1 = 5.0$ μF, $C_2 = 1.0$ μF, $C_3 = 2.0$ μF and $C_4 = 3.0$ μF. Find the equivalent capacitance of the network of capacitors.



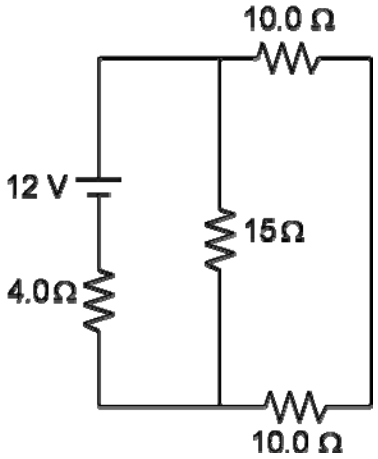
A. 0.49 μF
B. 2.7 μF
C. 5.5 μF
D. 5.8 μF
E. 11 μF

5. How much power is lost as heat along the length of a 15 m long wire in the walls of your house? [The wire is made of solid aluminum, has a diameter of 2.0 mm, and carries 12 A of current. The resistivity of aluminum is 2.8×10^{-8} Ω m.]
   A. 4.0×10^{-6} W
   B. 0.13 W
   C. 1.6 W
   D. 4.8 W
   E. 19 W

6. The digital multimeters you used in practicals can be set to either *voltmeter* mode, to measure voltage, or *ammeter* mode, to measure current. You have a battery which is currently illuminating a light bulb. You wish to use your multimeter to measure the voltage drop across this light bulb, or the current running through it. You should connect the multimeter to the light bulb in
   A. series to measure voltage, in *voltmeter* mode, or parallel to measure current, in *ammeter* mode.
   B. parallel to measure voltage, in *voltmeter* mode, or series to measure current, in *ammeter* mode.
   C. series to measure voltage, in *voltmeter* mode, or series to measure current, in *ammeter* mode.
   D. series to measure voltage, in *voltmeter* mode, or series to measure current, in *ammeter* mode.
   E. series to measure voltage, in *voltmeter* mode, but you cannot use the multimeter to measure current.

7. What is the current being drawn through the battery of the circuit shown?

   A. 0.31 A
   B. 0.95 A
   C. 1.5 A
   D. 4.4 A
   E. 6.2 A



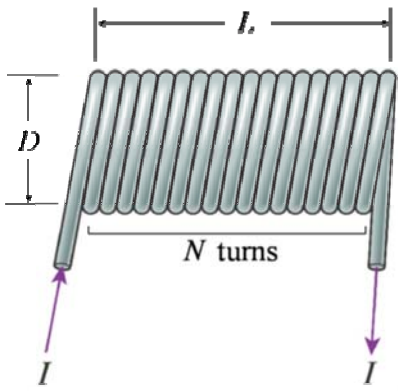
8. An electric power line carries a steady current of 150 A toward the North. At a distance of 5 m below the wire, a golf-ball flies by, traveling directly West. The golf ball has a net negative charge on it. What is the direction of the magnetic force on the ball due to the current in the wire?
   A. North
   B. South
   C. up
   D. down
   E. the wire produces zero magnetic force on the ball

FREE-FORM IN TWO UNRELATED PARTS (12 points total)

Clearly show your reasoning and work as some part marks may be awarded. Write your final answers in the boxes provided.

PART A

A solenoid has length L, diameter D, and N turns, each carrying current I.



A1. (1 point) Assuming I is a positive number, what is the direction of the magnetic field at the centre of the solenoid? [Circle the best choice from the following six possibilities:]

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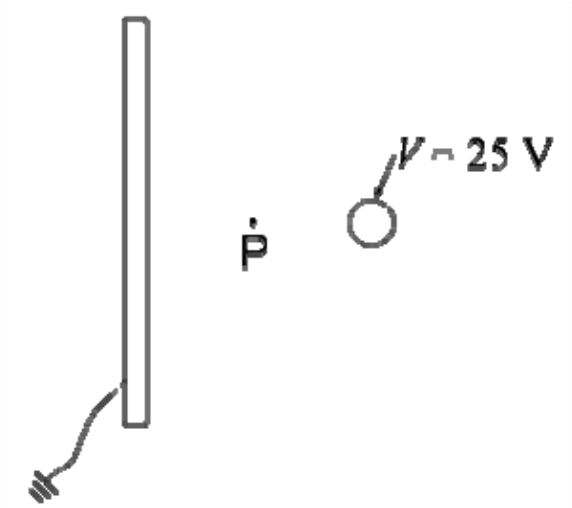
A2. (5 points) If L is much greater than D, then far from the ends of the solenoid, the magnetic field is axial, which means it is parallel to the axis of the solenoid. Assume L is much greater than D, and use Ampère's law to find the magnitude of the magnetic field at the centre of the solenoid, in terms of L, D, N, I and universal constants. Please add to the picture above a sketch of the integration path you are using in your line integral.

PART B

A large, flat conducting plate is grounded, so that its electric potential is 0. A nearby small conducting sphere is held at an electric potential of 25 V. The shortest distance between the edge of the plate and the sphere is 6.0 cm. A mid-way point P is 3.0 cm away from the plate and 3.0 cm away from the sphere. The situation is shown from the side in the sketch below.



B1. (2 points) Estimate the electric potential at the point P.

B2. (1 point) What is the direction of the electric field at point P?
[Circle the best choice from the following six possibilities:]

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B3. (3 points) Estimate the magnitude of the electric field at point P.

ROUGH WORK (not marked)