**Student Name:**
**Student ID:**

COURSE **ELECTRICAL ENGINEERING 2FH3**

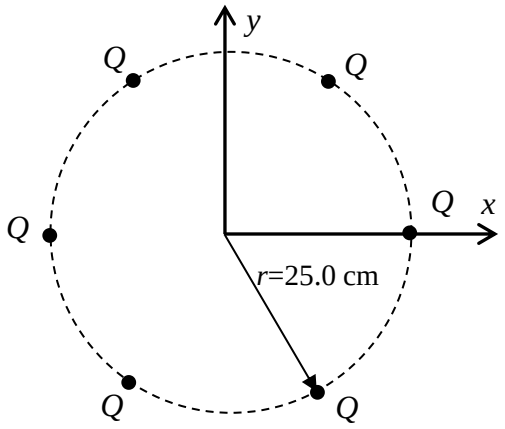
Duration of Examination: **2 hours**
**Midterm Examination** February 27th, 2014

THIS EXAMINATION PAPER INCLUDES **2 PAGES** AND **5 QUESTIONS.** YOU ARE RESPONSIBLE FOR ENSURING THAT YOUR COPY OF THE PAPER IS COMPLETE. BRING ANY DISCREPANCY TO THE ATTENTION OF YOUR INVIGILATOR.

Instructions:
1. You can use only a standard calculator (Casio-FX991).
2. Write your name and student ID on each page, the exam booklets incl.
3. You are allowed to bring 1 sheet of letter-size paper with any writing on both sides of the sheet.
4. Attempt all questions.

**Question 1** [20 points]

Six equal point charges of value $Q$=2.0 nC are uniformly positioned on the circumference of a circle of radius 25.0 cm in the $xy$ plane as shown.

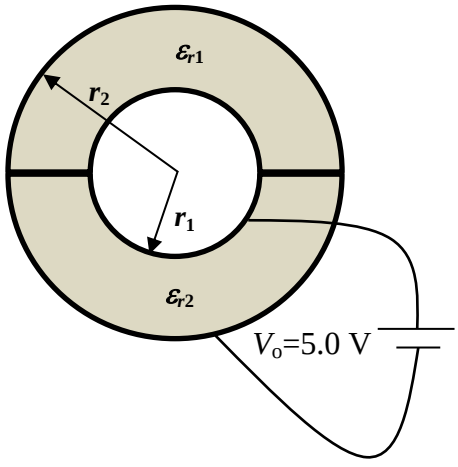



a) Find the electric field at the point (0,0,0) m.
b) Find the electric potential at the same point in (a).
c) Find the electric potential at the point (0,0,1.0) m.
d) Find the electric field at the same point in (c).
e) What is the force affecting a test charge of value 0.1nC at the point (0,0, 1.0) m?

**Question 2** [30 points]

Consider the shown spherical capacitor.

The inner sphere is perfectly conducting and has a radius of $r_1$=2.0 cm. The outer metal shell has a radius of $r_2$=3.0 cm. The spherical region between the two electrodes is filled with two different types of dielectrics. For $0 \le \theta \le \pi/2$, the relative permittivity is $\varepsilon_{r1}$=2.0. For $\pi/2 \le \theta \le \pi$, the relative permittivity is $\varepsilon_{r2}$=3.0. Both dielectrics are assumed ideal.




a) Find the electric field intensity **E** everywhere.
b) Find the electric flux density **D** everywhere.
c) Find the total charge on the positive electrode.
d) Find the capacitance of the capacitor.
e) What is the total electric energy stored in this capacitor?

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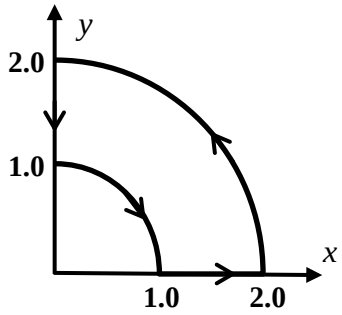
**Question 3** [20 points]
Verify Stoke's theorem for the vector field $\mathbf{B} = \rho\cos(\varphi)\boldsymbol{a}_\rho + \sin(\varphi)\boldsymbol{a}_\varphi$ using the shown contour. All shown dimensions are in meters.




**Question 4** [25 points]
An air-filled cube is defined by $1 \le x \le 1.2$, $1 \le y \le 1.2$, and $1 \le z \le 1.2$, where the limits are in meters. The electric flux density in the cube is given by $\mathbf{D} = 2x^2y\mathbf{a}_x + 3x^2y^2\mathbf{a}_y$, C/m$^2$.
a) Find the charge density $\rho_v$ as a function of position ($x$,$y$,$z$).
b) Find the total charge enclosed by the cube.
c) What is total electric flux out of this cube?
d) Find the electric field vector **E** in the cube as a function of position ($x$,$y$,$z$).
e) Find the potential difference $V_A$–$V_B$ between the points $A$(1, 1.2, 1) and $B$(1.2, 1, 1). Coordinates are in meters.

**Question 5** [15 points]

If the electrostatic potential is given by $V=3x^2+6y^2$ V in free space, find the energy stored in the volume defined by $-1.0 \le x \le 1.0$, $-1.0 \le y \le 1.0$, and $-1.0 \le z \le 1.0$. All dimensions are in meters.

**END OF QUESTION SHEET**
**TOTAL MARKS FOR THIS EXAM = 100 plus 10 bonus marks**