Institutt for fysikk, NTNU
TFY4155/FY1003: Elektrisitet og magnetisme
Vår 2005

Øving 8

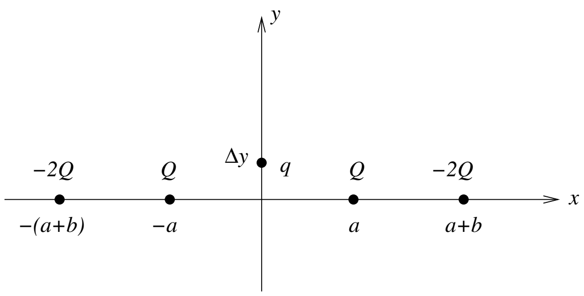
Guidance: 01.03, 02.03, 03.03, 04.03, 08.03, 09.03, 10.03
(In auditorium, not in the small rooms. See guidance plan on the home page.)
To be delivered by: Monday March 14 at 12 noon. (Table for your answers on last page.)

Information:

- Unless otherwise stated, it is assumed that the system is in electrostatic equilibrium.
- Unless otherwise stated, "potential" means "electrostatic potential", and correspondingly for "potential energy".
- Unless otherwise stated, zero (electrostatic) potential and potential energy is chosen infinitely far away.
- You may need some of these: $1/4\pi\varepsilon_0 = 9 \cdot 10^9$ Nm^2/C^2, $e = 1.6 \cdot 10^{-19}$ C, $m_e = 9.11 \cdot 10^{-31}$ kg, $m_p = 1.67 \cdot 10^{-27}$ kg, $g = 9.8$ m/s^2
- Symbols are given in italics (e.g. V for potential) while units are given without italics (e.g. V for volt).

1) Four point charges are located on the x axis, as shown in the figure. Positive charges Q in $x = a$ and $x = -a$, negative charges $-2Q$ in $x = a + b$ and $x = -(a + b)$. A positive test charge q can move without friction along the y axis. It is released, with zero velocity, from its starting position $y = \Delta y$ on the positive y axis. What happens with the test charge q?

A It will move to $y = \infty$.
B It will oscillate back and forth around the origin.
C It will oscillate around an equilibrium position $y_0 > 0$.
D Both A, B and C are possible; the outcome depends on the ratio b/a.



2) A proton
A has a charge 1/2000 of the electron charge.
B has a charge 2000 times that of the electron.
C has about 2000 times larger mass than the electron.
D has a mass about 1/2000 of the electron mass.

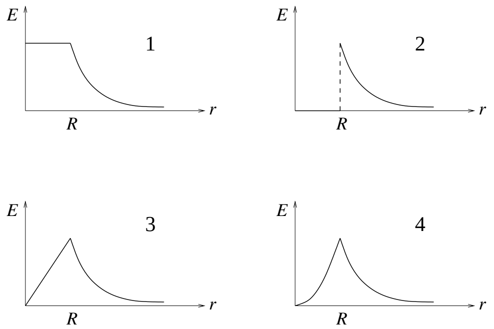
3) Two spheres, 1 and 2, have equal radius R and equal charge Q. The spheres don't interact with each other. Sphere 1 has its charge uniformly distributed over its surface, sphere 2 has its charge uniformly distributed over the entire volume. Sphere 1 has potential energy U_1, sphere 2 has potential energy U_2. Identify the correct answer!

A $U_1 = Q^2/8\pi\varepsilon_0 R$, $U_2 = Q^2/20\pi\varepsilon_0 R$
B $U_1 = Q^2/8\pi\varepsilon_0 R$, $U_2 = Q^2/10\pi\varepsilon_0 R$
C $U_1 = Q^2/8\pi\varepsilon_0 R$, $U_2 = 3Q^2/20\pi\varepsilon_0 R$
D $U_1 = Q^2/8\pi\varepsilon_0 R$, $U_2 = 3Q^2/40\pi\varepsilon_0 R$

[Hint: What does an electric conductor prefer?]

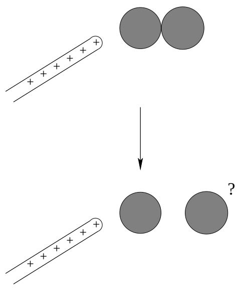
4) Two metal spheres attract each other electrostatically. Which statement is then always true?
A Both spheres have a net charge.
B At least one of the spheres has a net charge.
C None of the spheres are charged.
D The spheres have the same kind of charge.

5) A sphere with radius R has charge pr unit volume that is inversely proportional with the distance r from the centre: $\rho(r) = k/r$ (k = constant). Determine, using Gauss' law, which graph in the figure that represents the resulting electric field strength $E(r)$. [Don't worry about the fact that the charge density $\rho \to \infty$ when $r \to 0$. Still, the charge on the sphere is finite.]



A 1
B 2
C 3
D 4

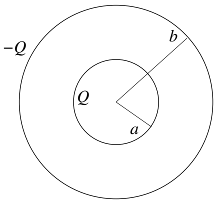
6) You bring a positively charged glass rod almost in touch with one (the one to the left) of two neutral metal spheres that are initially in contact with each other. Then you separate the two metal spheres from each other. Now, the sphere to the right has



A positive charge.
B negative charge.
C the same charge as the sphere to the left.
D nonzero net charge, but the sign cannot be determined.

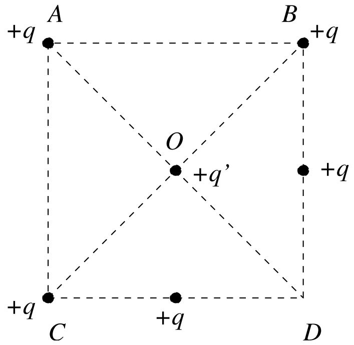
7) Two concentric (thin) metallic spherical shells have radius a and b, respectively ($b > a$), and charge Q and $-Q$. What is the capacitance of this capacitor? (Hint: Find the potential difference between the inner and outer spherical shell.)

A $4\pi\varepsilon_0 ab/(b-a)$
B $\pi\varepsilon_0(b-a)$
C $4\pi\varepsilon_0 a^2/(b-a)$
D $4\pi\varepsilon_0(b-a)^3/3ab$



8) Five equal point charges $+q$ are placed on a square as shown in the figure. A sixth charge $+q'$ is placed in the center of the square, in position O. In which direction is the net force on the charge q'?

A Along OA.
B Along OB.
C Along OC.
D Along OD.

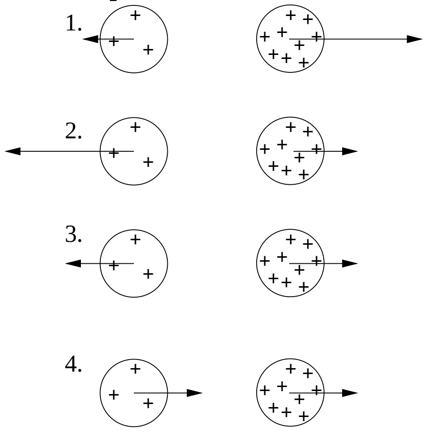


9) Three metal spheres are hanging in thin, electrically insulating wires. When you hold spheres 1 and 2 near each other, you observe that they attract each other. When you do the same with spheres 2 and 3, you notice that they repel each other. Then you can conclude that

A spheres 1 and 3 have charge with opposite sign.
B spheres 1 and 3 have charge with the same sign.
C one of the spheres is electrically neutral.
D we do not have enough information to decide the sign of the charge on all three spheres.

10) Two uniformly charged spheres have charges Q and $3Q$, respectively. Which figure describes correctly the electrostatic forces acting on the two spheres?

A 1.
B 2.
C 3.
D 4.



11) The electric field on the symmetry axis and in distance x from the centre of a uniformly charged circular disk with charge Q and radius R is

A $\quad \dfrac{Q\left(1 - x/\sqrt{x^2+R^2}\right)}{2\pi\varepsilon_0 R^2}$

B $\quad \dfrac{Q\left(1 - R/\sqrt{x^2+R^2}\right)}{2\pi\varepsilon_0 R^2}$

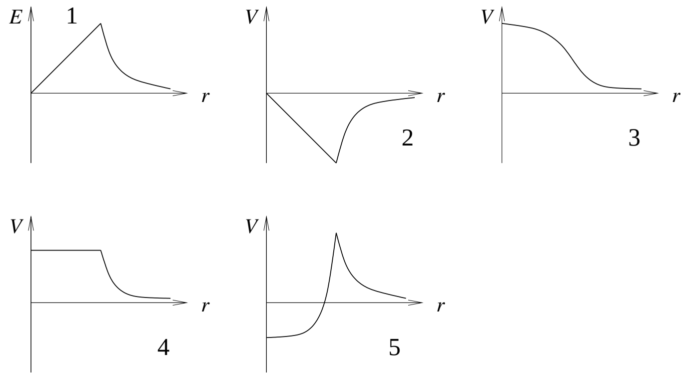
C $\quad \dfrac{Q\left(1 + R/\sqrt{x^2+R^2}\right)}{2\pi\varepsilon_0 R^2}$

D $\quad \dfrac{Q\left(1 + x/\sqrt{x^2+R^2}\right)}{2\pi\varepsilon_0 R}$

Hint: Consider certain limit(s) of the given alternatives instead of performing the calculation.

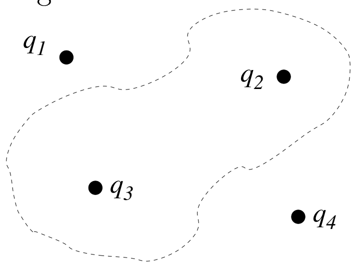
12) If the electric field E as function of distance r from a charge distribution is as shown in graph 1, which graph then shows the electric potential V as function of r? (Hint: Remember that $\boldsymbol{E} = -\nabla V$, with spherical symmetry $E(r) = -dV/dr$.)

A 2
B 3
C 4
D 5



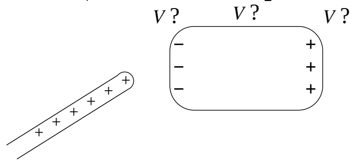
13) The figure to the right shows 4 point charges and a gaussian surface (dashed). Which charges contribute to the net electric flux through the gaussian surface?

A Only q_1 and q_4.
B Only q_2 and q_3.
C All four of them.
D The answer depends on the shape of the gaussian surface.



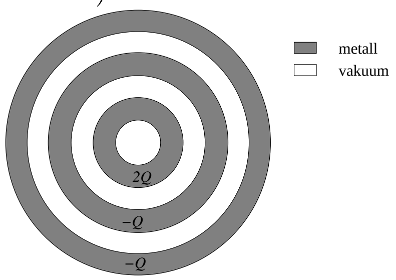
14) A charged glass rod is brought in the vicinity of an electrically neutral piece of metal, so that the metal obtains an excess negative and positive charge on the left and the right side, respectively, as shown in the figure. On the piece of metal, the electric potential is

A constant everywhere.
B biggest on the positively charged side.
C biggest on the negatively charged side.
D biggest in the middle.



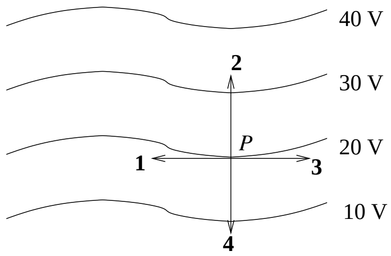
15) The figure shows three hollow concentric metal spheres with net charge $2Q$ (on the inner sphere), $-Q$ (on the sphere in the middle) and $-Q$ (on the outermost sphere). All the three metal spheres have a finite thickness. How much charge is on the *outer* surface of the sphere *in the middle*? (Hint: Gauss' law and $E = 0$ inside a metal.)

A $-Q$
B $-2Q$
C Q
D 0



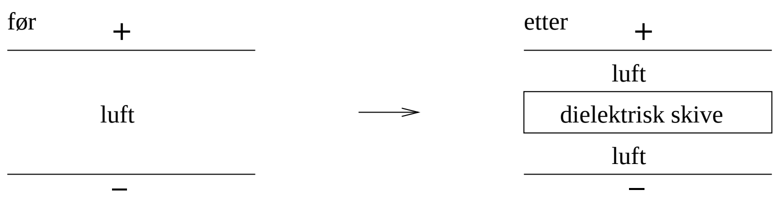
16) Which vector represents best the direction of the electric field in the point P on the 20-volt equipotential surface?

A **1**
B **2**
C **3**
D **4**



17) A parallel plate capacitor has charge Q and $-Q$ on the upper and lower plate, respectively. The capacitor is initially filled with air, but then a dielectric slab (with the same area as the metal plates) is pushed in between the metal plates, as shown in the figure. Which one of the following four statements is then correct?

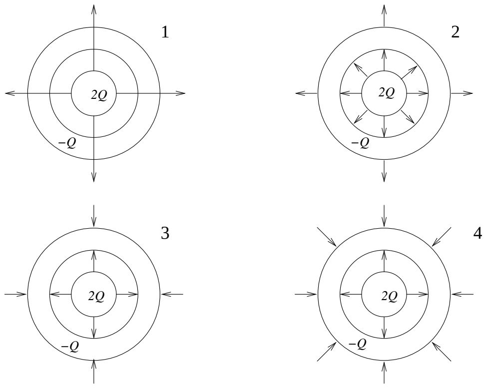
A The potential difference between the metal plates remains unchanged.
B The capacitance of the capacitor remains unchanged.
C The potential energy stored in the capacitor remains unchanged.
D The electric field strength in the layers filled with air remains unchanged.



18) What is not a possible unit for electric field E?

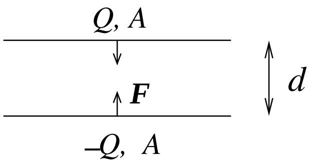
A N/C
B V/m
C kg m^2/s^2 C
D N/VF

19) The figure shows a metal sphere with net charge $2Q$ surrounded by a layer of air, followed by a metallic spherical shell with net charge $-Q$. Which figure describes correctly the field lines for $\boldsymbol{E}$? (Hint: Gauss' law and $E = 0$ inside a metal.)



A 1
B 2
C 3
D 4

20) Two (approximately infinitely) large parallel metal plates have equal area A and net charge Q and $-Q$, respectively. The distance between the plates is d ($d \ll \sqrt{A}$). How big is the mutual force pr unit area, $f = F/A$, between the two plates when $\sigma = Q/A = 10^{-5}$ C/m^2?



A 5.7 N/m^2
B 88 N/m^2
C 245 N/m^2
D 1.6 kN/m^2

Øving 8 i Elektromagnetisme / Elektrisitet og magnetisme våren 2005

To be delivered by: Monday March 14 at noon.

Name:

Group:

Exercise	A	B	C	D
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It is sufficient to deliver this table, filled in with your answers, before the deadline in order to get this one approved.