Department of Physics, NTNU

Examination paper for FY1003 Electricity and Magnetism

Examination date: 11.05.2022

Examination time (from-to): 15:00-19:00

Permitted examination support material: D / Simple calculator

Academic contact during examination: Raffaela Cabriolu
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OTHER INFORMATION

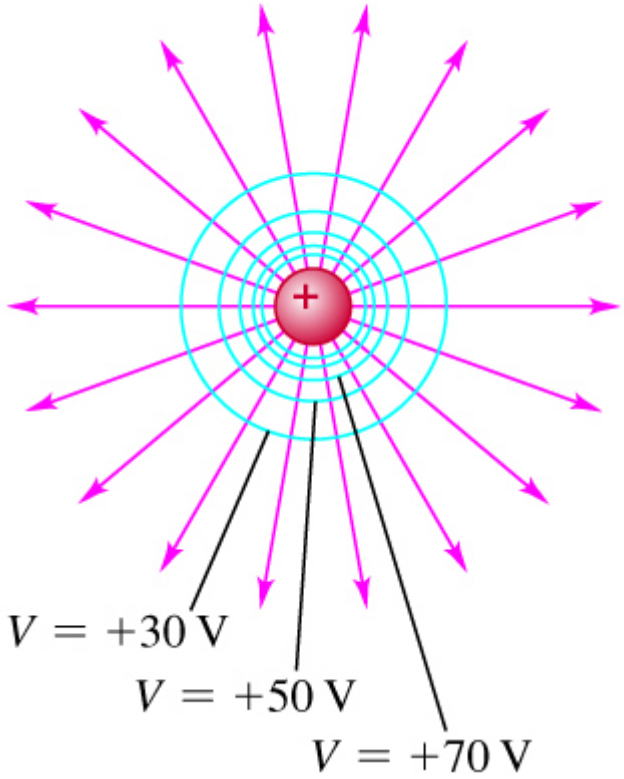
Only contact academic contact in case of errors or insufficiencies in the question set.

Notifications: If there is a need to send a message to the candidates during the exam (e.g. if there is an error in the question set), this will be done by sending a notification in Inspera. A dialogue box will appear. You can re-read the notification by clicking the bell icon in the top right-hand corner of the screen.

Withdrawing from the exam: If you become ill or wish to submit a blank test/withdraw from the exam for another reason, go to the menu in the top right-hand corner and click “Submit blank”. This cannot be undone, even if the test is still open.

Access to your answers: After the exam, you can find your answers in the archive in Inspera. Be aware that it may take a working day until any hand-written material is available in the archive.

1 Consider the figure below.



1. Would the shape of the equipotential surfaces change if the sign of the charge is reversed?
Select one alternative:

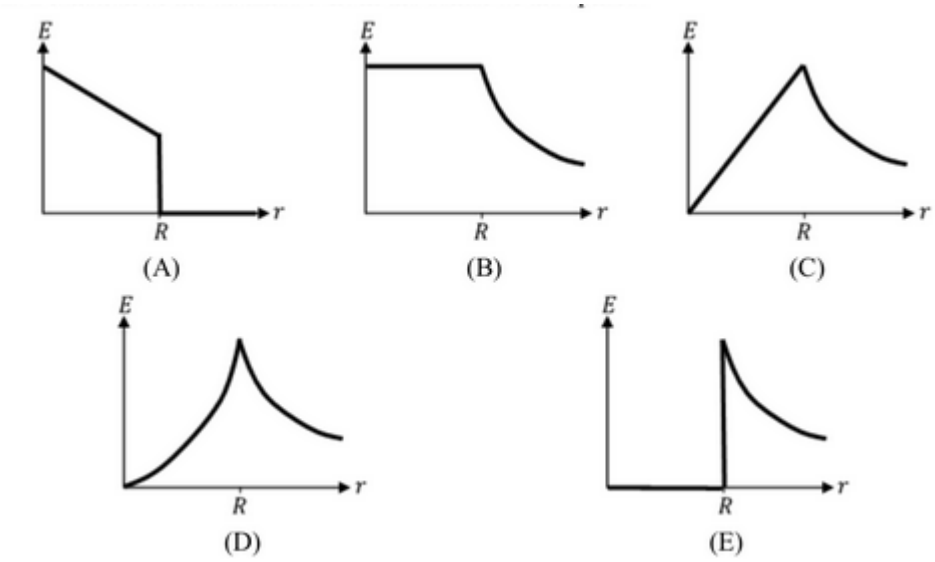
- Yes
- No

2. Will the potential at the indicated equipotential surfaces change?
Select one alternative

- Yes
- No

Maximum marks: 2

2 The following graphs show the electric field at a variable distance r.



Which one corresponds to the electric field generated by a charged spherical conductor of radius R?

Select one alternative:

- B
- C
- D
- A
- E

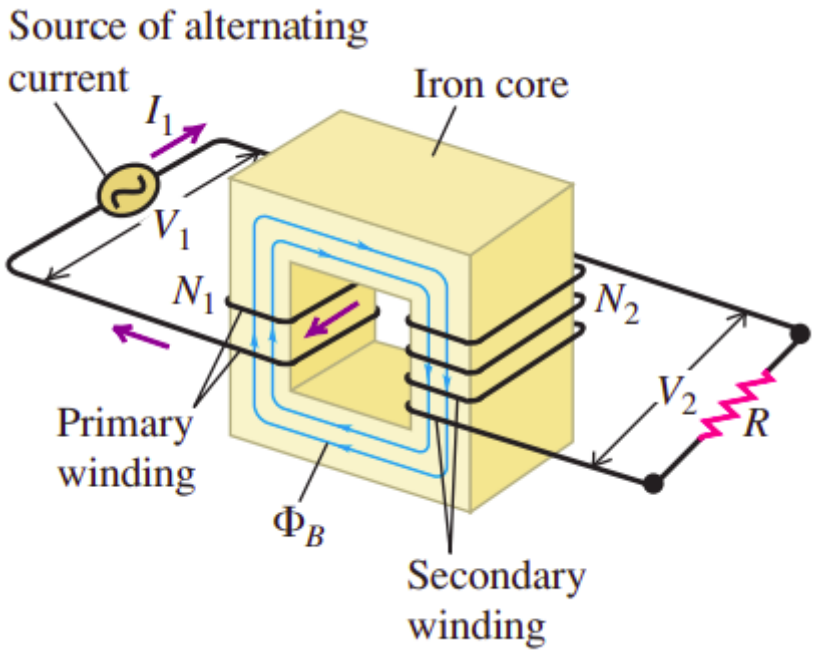
Which one corresponds to the electric field generated by a uniformly charged insulating sphere of radius R?

Select one alternative:

- A
- D
- E
- C
- B

Maximum marks: 4

3 Linnea is moving out from Norway for six months of study experience in the USA. She would like to use her 960 W coffeemaker bought in Norway. She needs a transformer to convert the 120 V ac to the 230 V that the coffeemaker requires to function. The voltages are root mean square values.



What is the ratio between the number of turns in the secondary winding (i.e., N_2) and the number of turns in the primary winding (i.e., N_1) of the transformer that she needs to buy?

Select one alternative:

- $\frac{N_2}{N_1} = 19.2$
- $\frac{N_2}{N_1} = 0.52$
- $\frac{N_2}{N_1} = 1.92$
- $\frac{N_2}{N_1} = 5.28$
- $\frac{N_2}{N_1} = 0.02$

What current will the coffeemaker draw from the 120 V supply?

Select one alternative:

- 10.0 A
- 4.0 A
- 3.0 A
- 8.0 A

Maximum marks: 4

4 Imagine the two conductors of a parallel plate capacitor having different plate area. Such a capacitor is fully charged by connecting the plates to a battery. Will the charge on the two plates be of the same magnitude, or of different magnitude?

Select one alternative:

- In a parallel plate capacitor, the amount of charge is proportional to the plate area. Hence, there is more charge on the large plate than on the small plate.
- The capacitor must be neutral. The two plates have the same amount of charges.

Maximum marks: 4

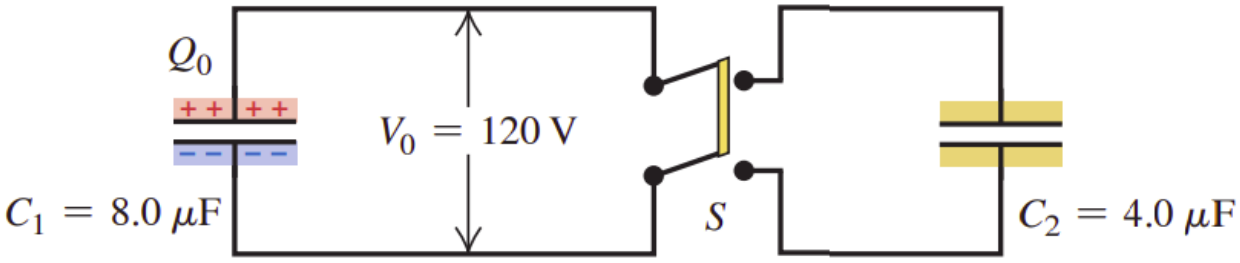
5 Consider the capacitor in the picture below. The parallel-plate capacitor is made of two squared plates of area 1.44 x 10^{-2} m^2 on each side and 4.50 mm apart. Half of the space in between the two plates is filled with air, and, the other half is filled with Plexiglas of dielectric constant 3.40. What is the capacitance of this system? *(Hint: Consider if this capacitor can be seen as a combination of two different capacitors connected in parallel, each with plates of area 7.20 x 10^{-3} m^2)*

Select one alternative:

- 62.3 pF
- 6.23 pF
- 6.23 μF
- 62.3 μF

Maximum marks: 4

6 Consider the circuit below. The capacitance C_1 and C_2 of the two capacitors are indicated in the figure, as well as the potential difference V_0.



Initially, the switch S is open. What is the energy stored in capacitor C_1?

Select one alternative:

- 3.0 J
- 0.058 J
- 0.20 J
- 0.5 J
- None of the alternatives are correct.

What is the total energy stored by the two capacitors after the switch S has been closed and the charge has been redistributed?

Select one alternative:

- 0.038 J
- None of the alternatives are correct.
- 0.13 J
- 0.32 J
- 3.2 J

Maximum marks: 8

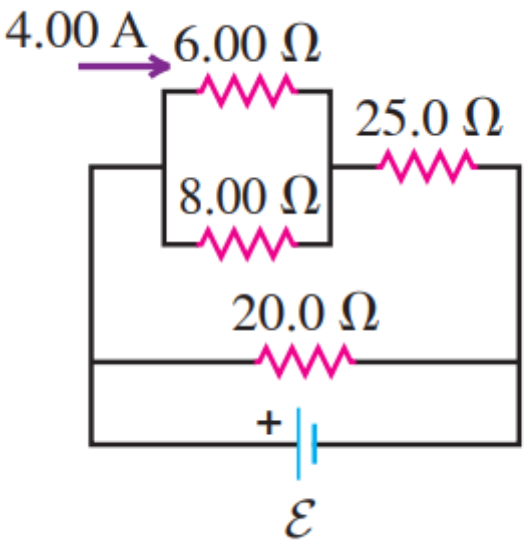
7 Estimate the drift velocity, v_d, for electrons in a cylindrical copper wire with a diameter d equal to 0.30 cm. The wire carries a current of 2.00 A. You can assume one free electron per copper atom. Furthermore, consider that the mass density of copper is 8.92 g/cm^3, and its molecular weight is 63.5 g/mol.
Remember the following constants:
Avogadro's number $N_A = 6.022 \cdot 10^{23}$ mol^{-1}
The electron charge $e = 1.602 \cdot 10^{-19}$ C.

Select one alternative:

- $V_d = 12.08 \times 10^{-9}$ cm/s
- $V_d = 2.08 \times 10^{-3}$ cm/s
- $V_d = 8 \times 10^{3}$ cm/s

Maximum marks: 4

8 Consider the circuit below. The current through the 6.00 Ω resistor is 4.00 A, with the direction indicated in the figure.



What is the current through the 25.0 Ω resistor?
Select one alternative:

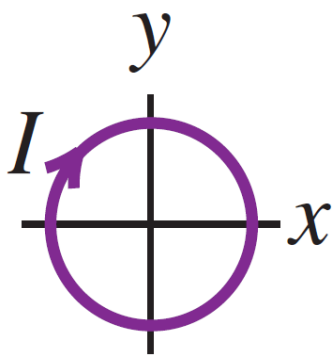
- 10.0 A
- 20.0 A
- 3.0 A
- 7.0 A

What is the current through the 20.0 Ω resistor?
Select one alternative:

- 7.0 A
- 20.0 A
- 15.0 A
- 9.95 A

Maximum marks: 4

9 Consider the circular coil in the figure. The coil is immersed in a uniform magnetic field that points in the +z-direction, i.e. out of the page. The coil is free to rotate around the y-axes and the x-axes.



What is the direction of the dipole moment of this coil?
Select one alternative:

- The dipole moment is directed in the -z direction, i.e. into the page.
- The dipole moment is directed in the -y direction.
- The dipole moment is directed in the +z direction, i.e. out of the page.
- The dipole moment is directed in the +x direction.

Is the coil in a rotational equilibrium condition?
Select one alternative:

- None of the alternatives are correct.
- Yes, it is in an unstable equilibrium condition.
- Yes. The torque of the force is always zero in a uniform magnetic field.
- Yes. It is in an equilibrium stable condition.
- No. It is rotating around the x-axes because the torque of the force is different than zero.
- No. It rotates because the magnetic flux is changing.

Is the coil attracted or repulsed by the external magnetic field?

Select one alternative:

- The net force on a current loop in a uniform magnetic field is zero.
- It is attracted by the source of the magnetic field.
- None of the alternatives are correct.
- It is repulsed by the source of the magnetic field.

Maximum marks: 5

10 A topic of interest in physics research is the existence of an isolated magnetic pole or magnetic monopole. What is the Maxwell's equation that excludes the existence of the magnetic monopole?

Select one alternative:

- Faraday's law.
- Gauss's law for magnetic fields.
- Ampere's law.
- Gauss's law for electric fields.

If such an entity were found, how could it be recognized?

Select one alternative:

- None of the alternatives is correct.
- The Faraday's law would be equal to the Gauss's law.
- The displacement current would be the same as the standard current.
- The magnetic flux through a closed surface would be proportional to the net number of magnetic monopoles included in the surface.

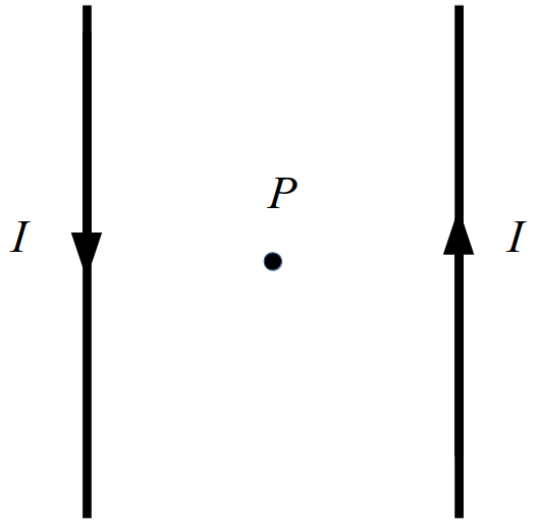
Maximum marks: 4

11 What feature of the material determine whether it is diamagnetic or paramagnetic?
Select the true alternative:

- The presence of imbalanced electric charges. Paramagnetic materials have a non null total electric charge while diamagnetic materials have zero total electric charges.
- The presence of total magnetic moment. Paramagnetic materials have a non null total magnetic moment while diamagnetic materials have zero total magnetic moment.
- None of the alternatives is correct.
- The presence of total magnetic moment. Paramagnetic materials have a null total magnetic moment while diamagnetic materials have non zero total magnetic moment.

Maximum marks: 4

12 Two wires lie in the plane of the page, and each carries a current of the same magnitude. However, those two currents have opposite directions as shown in the picture.

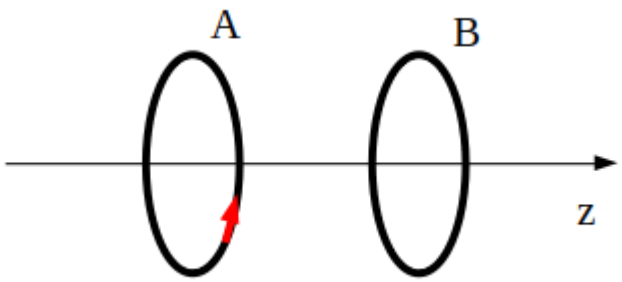


The magnetic field at the point P is:
Select one alternative:

- Out of the page.
- zero.
- into the page.
- Parallel to one of the wire currents.
- Toward one of the two wires.

Maximum marks: 4

13 The planes of the circular loops in the picture are parallel. As viewed from the left, the current in the loop A is counterclockwise.



If the magnitude of the current in the loop A is increasing, what is the direction of the current induced in loop B?

Select one alternative:

- There is no current in the loop B.
- Clockwise.
- Counterclockwise.

Do the loops attract or repel each other?

Select one alternative

- They repel each other.
- There is no force between them.
- The torque of the force is different than zero.
- They attract each other.

Maximum marks: 4

14 Match the following statements with the electromagnetism Equations of Maxwell.

(a) Only changing magnetic fields produce closed electric field lines.

(b) Electric field lines can start from positive and end in negative charges.

(c) Motion of electric charges and variation of electric fields produce closed magnetic field lines.

(d) Magnetic monopoles do not exist.

$$(1)\oint \vec{B}\cdot\vec{dA}=0$$

$$(2)\oint \vec{E}\cdot\vec{dA}=\frac{Q_{enclosed}}{\epsilon_0}$$

$$(3)\oint \vec{E}\cdot\vec{dl}=-\frac{d\Phi_B}{dt}$$

$$(4)\oint \vec{B}\cdot\vec{dl}=\mu_0\left(i_C+\epsilon_0\frac{d\Phi_E}{dt}\right)$$

Please match the values:

	(4)	(2)	(3)	(1)
(b)	○	○	○	○
(a)	○	○	○	○
(d)	○	○	○	○
(c)	○	○	○	○

Maximum marks: 4

15 The following sentences refer to properties related to magnetic and electric fields. Mark the ones you think are true.

Select one or more alternatives:

- [ ] Magnetic forces between magnet bars are always attractive, electric forces between point charges can be attractive or repulsive.
- [ ] The strength of the magnetic and electric field is indicated by the closeness of the field lines.
- [ ] Electric fields are generated by stationary and moving charges, while magnetic fields are generated only by moving charges.
- [ ] Magnetic forces between magnet bars and electric forces between point charges can be attractive or repulsive.
- [ ] Magnetic fields are always non conservative, electric fields can be both conservative and non conservative.
- [ ] Magnetic and electric fields are always conservative.
- [ ] Magnetic and electric fields generate forces inversely proportional to the square of the distance between the sources.

Maximum marks: 4

16

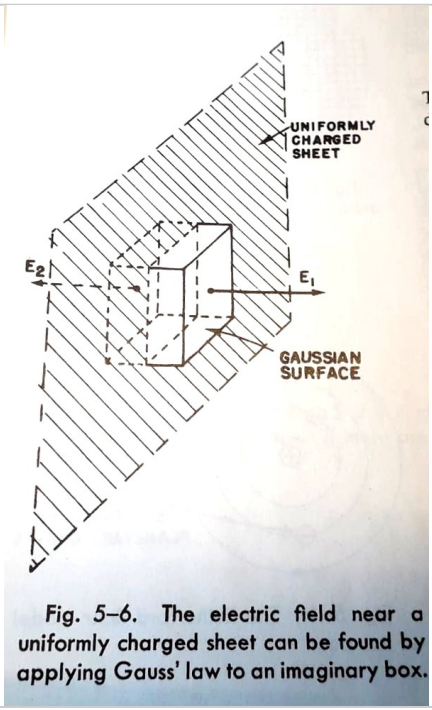


Fig. 5–6. The electric field near a uniformly charged sheet can be found by applying Gauss' law to an imaginary box.

The following paragraph has been extracted from the "Feynman Lectures of Physics" Volume II. Choose the word you think is correct among the alternatives offered in each menu.

We calculate the field from a Select alternative (non uniform, uniform) plain sheet of charge. Suppose that the sheet is infinite and that the Select alternative (charge per unit area, charge per unit volume, charge per unit length, charge) is σ .
Consideration of symmetry leads us to believe that the field direction is everywhere Select alternative (parallel, normal) to the plane, and, if we have no field from any other charges in the world, the field must be Select alternative (the same, half , different, null) on each side.
This time we choose as Gaussian Select alternative (volume, line , surface) a rectangular box that cuts the sheet. The two faces parallel to the sheet have equal area A. The electric field is Select alternative (parallel, normal) to these two faces, and Select alternative (normal, parallel) to the other four. The total Select alternative (magnetic field, electric field, charge, electric flux) is E times the area of the first face, plus E times the area of the opposite face, with no contribution from the other four faces. The total Select alternative (charge, volume, flux, area) enclosed in the box is σA. Equating the Select alternative (electric field , electric flux , magnetic field, magnetic flux) to the charge inside, we have:

$$EA + EA = \frac{\sigma A}{\epsilon_0}$$

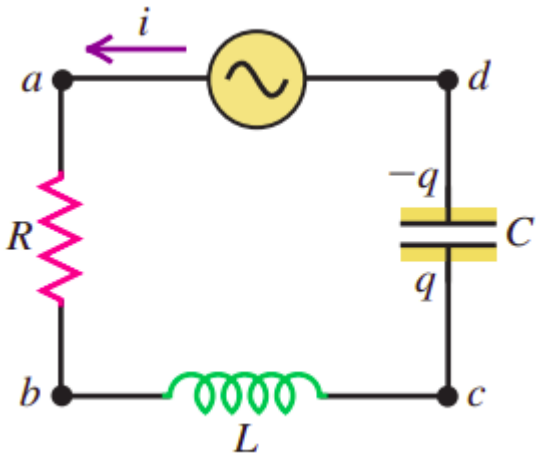
from which:

$$E = \frac{\sigma}{2\epsilon_0} \qquad (5.3)$$

a simple but important result.

Maximum marks: 5

17 In the LRC series circuit of the figure below, suppose R = 300Ω, L=40 mH, C= 0.50 x 10^{-6} F, V = 50V and ω=1.0 x 10^{4} rad/s. Remember that V represents the voltage amplitude.



What is the **power factor** of the circuit?

Select one alternative:

- 5
- 0.60
- 0.83
- 0.90
- 10
- 0.20

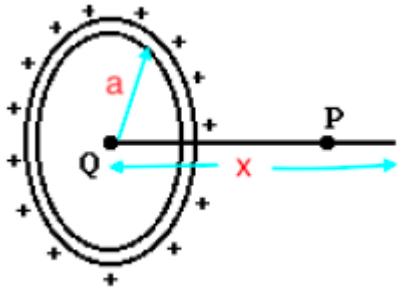
What is the **average power** delivered to the entire circuit?

Select one alternative

- 15W
- 50 W
- 2.9 W
- 600W
- 3.5W
- 7.0W

Maximum marks: 6

18



A point charge is placed at the middle of a conducting ring with radius *a* that has a total charge of *C* coulombs. If the electric field is measured to be zero at a point P on the axis, a distance *x* from the plane of the ring, what is the value of the charge, Q?

C= 210nC

x= 0.3 m

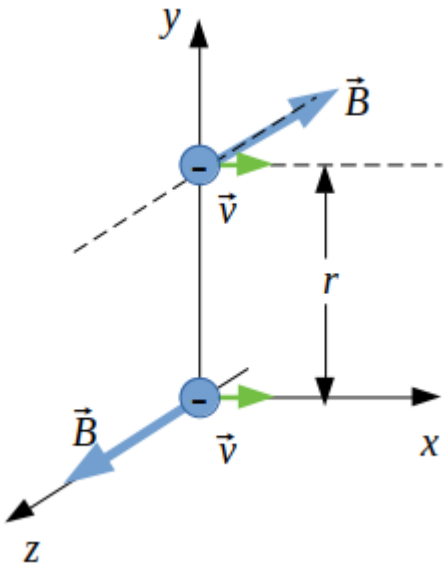
a= 0.49 m

Select one alternative:

- - 37 nC
- -30 nC
- -25 nC
- -47 nC
- -20 nC
- -71nC

Maximum marks: 2

19 Two electrons are traveling parallel to each other with same speed and in the same direction. Each electron is generating a magnetic field onto the other charge with the direction shown in the picture.



How is the magnetic force between the two charges?
Select one alternative:

- Repulsive.
- Attractive.
- Conservative.
- zero.

How is the electric force between them?

Select one alternative

- None of the alternatives is true.
- Attractive.
- Repulsive.
- Zero.

Maximum marks: 4