Elektromagnetno polje: 1. pisni izpit

(1. 2. 2017 ob 10:00)

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1. naloga

Dve enaki navpični tuljavi prostornine V sta postavljeni na skupno navpično os v medsebojni razdalji D, ki je velika v primerjavi z linearno razsežnostjo tuljav ($D \gg V^{1/3}$). Upornost tuljav je zanemarljivo majhna. V prvi tuljavi je sprva električni tok I_0, v drugi tuljavi pa ni toka. Nato tok v prvi tuljavi v času t_0 enakomerno zmanjšamo na nič.

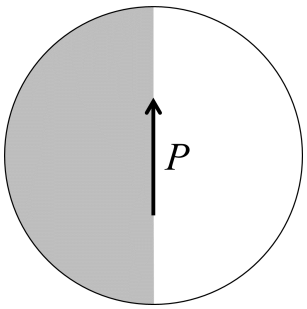
a) Nariši časovni potek toka v drugi tuljavi.

b) Izračunaj končno vrednost toka v drugi tuljavi.

Tuljavi obravnavaj kot magnetna dipola.

2. naloga

Dolg valj polmera a je izdelan iz snovi s homogeno konstantno polarizacijo P, ki kaže pravokotno na os valja, kakor v preseku prikazuje slika.

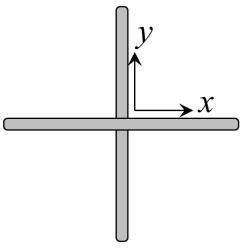


a) Izračunaj silo na dolžinsko enoto valja, ki deluje na osenčeno polovico valja.

b) V katero smer kaže ta sila?

3. naloga

Dve enaki krožni zanki sestavimo v oddajno anteno, tako da sta njuni ravnini navpični in pravokotni druga na drugo, središči zank pa sovpadata, kakor prikazuje slika (spodaj sta zanki v tlorisu). Zanki sta izolirani druga od druge, napajamo ju s sinusnim tokom, ki pa je v eni zanki fazno zamaknjen glede na drugo zanko za δ. Izračunaj odvisnost časovno povprečenega skupnega izsevanega energijskega toka takšne antene od faznega zamika δ, pri čemer se ne oziraj na predfaktor. Interpretiraj končni rezultat.



Zanki sta majhni glede na valovno dolžino valovanja, ki ga antena oddaja. Sevanje posamezne tokovne zanke je magnetno dipolno.

Matematični pripomoček:
Rešitve Laplaceove enačbe $\nabla^2 U(r,\varphi) = 0$ v polarnih koordinatah:

$$U(r,\varphi) = A_0 + B_0 \ln r + \sum_{m=1}^{\infty} \left(A_m r^m + B_m r^{-m}\right) \cos(m\varphi) + \sum_{m=1}^{\infty} \left(C_m r^m + D_m r^{-m}\right) \sin(m\varphi).$$

Čas reševanja: 90 minut.
Dovoljeni pripomočki: podani spisek enačb, matematični priročnik, kalkulator.
Rešitve nalog, ocene ter kraj in čas ogleda izpita bodo objavljeni na spletni strani `http://www-f5.ijs.si/emp-2016-2017.html`.

Electromagnetic field: 1st final examination

(1st of February 2017 at 10:00)

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Problem 1

Two identical vertical coils of volume V are placed on a common vertical axis, separated by a distance D, which is large compared to the linear dimensions of the coils ($D \gg V^{1/3}$). The resistance of the coils is negligible. Initially, there is an electrical current I_0 in the first coil and no current in the second coil. The current in the first coil is then linearly decreased to zero in time t_0.

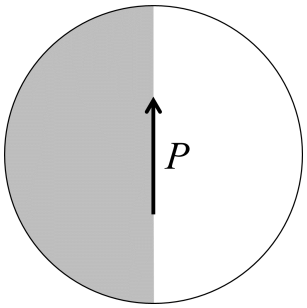
a) Draw the time dependence of the current in the second coil.

b) Determine the final current value in the second coil.

Treat the coils as magnetic dipoles.

Problem 2

A long cylinder of radius a is made of the material with a homogeneous constant polarization P directed perpendicular to the axis of the cylinder, with the cross-section shown in the figure.

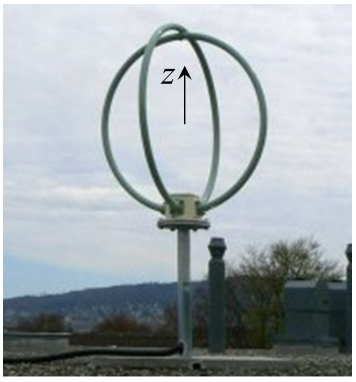


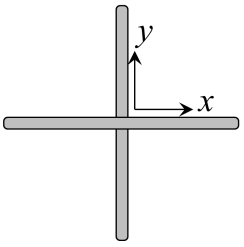
a) Determine the electric force per unit length of the cylinder acting on the sheded half of the cylinder.

b) What is the direction of this force?

Problem 3

A transmitting antenna is composed of two identical circular loops, so that their planes are vertical and perpendicular to each other, while the centers of the loops coincide, as shown in the figure (the bottom figure shows the loops from the top). The loops are isolated from each other and fed with the sinusoidal current, which is shifted in one loop by δ with respect to the other loop. Disregarding the prefactor, determine the dependence of the time-averaged total transmitted energy flux of such an antenna on the phase shift δ. Interpret the final result.





The loops are small compared to the wave length of the transmitted waves. The radiation of each loop is of magnetic dipole type.

Mathematical tool:
Solutions of the Laplace equation $\nabla^2 U(r,\varphi) = 0$ in polar coordinates:

$$U(r,\varphi) = A_0 + B_0 \ln r + \sum_{m=1}^{\infty} \left(A_m r^m + B_m r^{-m}\right) \cos(m\varphi) + \sum_{m=1}^{\infty} \left(C_m r^m + D_m r^{-m}\right) \sin(m\varphi).$$

Duration of examination: 90 minutes.
Allowed accessories: given list of equations, mathematical handbook, calculator.
Solutions of the problems, scores, and place and time of the access to the assessed exams will be announced on the website
`http://www-f5.ijs.si/emp-2016-2017.html`.
