Problems - Part 2

1. A proton is released from rest in a uniform electric field of 8×10^{4} V.m^{-1} directed along the positive *x*-axis as is shown in Fig. 1. The proton undergoes a displacement of 0,5 m in the direction of E .
   a) Find the change in the electric potential between the points A and B.
   b) Find the change in the potential energy of the proton for this displacement.
   c) Find the speed of the proton after it has been displaced from rest by 0,5 m.

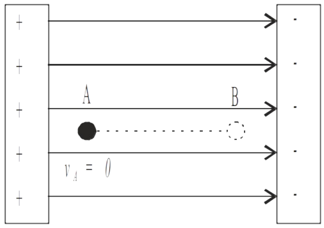

Fig. 1

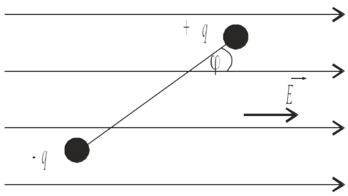

Fig. 2

2. An electric dipole in a uniform electric field is displaced slightly from its equilibrium position, as is shown in Fig.2, about the small angle φ . The dipole moment is $p = 2qa$ and moment of inertia of the dipole is *I*. If the dipole is released from this position, show that it exhibits simple harmonic motion with a frequency given by $f = \frac{1}{2\pi}\sqrt{\frac{pE}{I}}$.

3. A large flam sheet of charge has a charge per unit area of 9.0 μC/m^2. Find the electric field just above the surface of the sheet, measured from the sheet`s midpoint.

4. The electric field in the earth`s atmosphere is $E = 100$ N.C^{-1}, pointing downward. Determine electric charge on the earth.

5. A solid sphere of radius 40 cm has a total positive charge of 26 μC uniformly distributed throughout its volume. Calculate the electric field at the distance 0 cm and 60 cm.

6. The charge per unit length on a long straight filament is –90 μC/m. Find the electric field at the distance $d = 10\ \text{cm}$ from the filament.

7. Find the force per unit area on the charges on the surface of a conductor (Fig. 3).

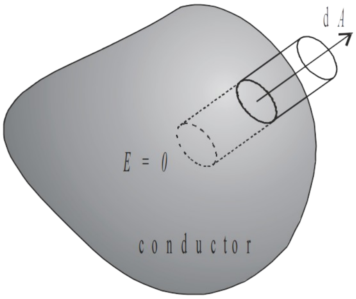

Fig. 3

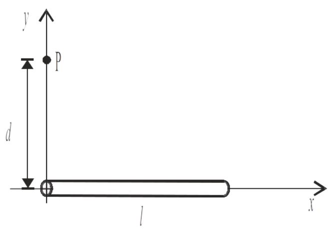

Fig. 4

8. A flat surface having an area of 3.2 m^2 is rotated in a uniform electric field of $E = 6.2 \times 10^5\ \text{N.C}^{-1}$. Calculate the electric flux through this area when the electric field
   a) is perpendicular to the surface
   b) is parallel to the surface
   c) makes an angle of 75° with the plane of the surface.

9. A rod of length *l* located along the *x*-axis has uniform charge per unit length and a total charge *Q*. Find the electric potential at a point P along the *y*-axis at a distance *d* from the origin. Situation is shown in Fig. 4.

10. A Geiger-Müller counter is a type of radiation detector that essentially consists of a hollow cylinder (the cathode) of inner radius r_a and the coaxial cylindrical wire (the anode) of radius r_b as is shown in Fig.5. The charge per unit length on the anode is λ, while the charge per unit length on the cathode is $-\lambda$.

   a. Show that the potential difference between the wire and the cylinder in the sensitive region of the detector is $V = 2k\lambda \ln \frac{r_a}{r_b}$.

   b. Show that magnitude of the electric field over that region is $E = \frac{V}{\ln\left(\frac{r_a}{r_b}\right)} \frac{1}{r}$, where r is the distance from the center of the anode to the point where the field is to be calculated.

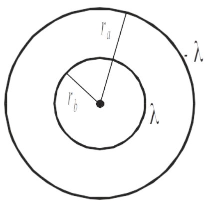

Fig. 5

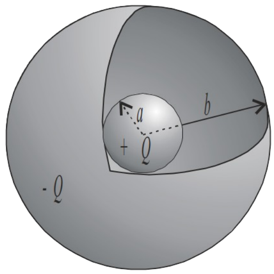

Fig. 6

11. A parallel-plate capacitor has an area of $A = 2 \times 10^{-4}\ \mathrm{m}^2$ and a plate separation of $d = 10^{-3}\ \mathrm{m}$. Calculate its capacitance.

12. A spherical capacitor consists of a spherical conducting shell of radius b and charge $-Q$ that is concentric with smaller conducting sphere of radius a and charge $+Q$ as is shown in Fig.6. Find its capacitance.

13. Calculate the resistance of a piece of alumunium that is 10 cm long has a cross-sectional area of 10^{-4} m^2. Resistivity of aluminium is 10^{10} Ω.m (glass).

14. A resistance thermometer made from platinium has a resistance 50.0 Ω at 20 °C. When it is immersed in a vessel containing melting indium, its resistance increases to 76.8 Ω. Find the melting point if indium. Coefficient of resistivity for platinum is $\alpha = 3.92 \times 10^{-3}\ C^{-1}$.

15. The gap between a pair of coaxial tubes is completely filled with silicon as is shown in Fig. 7. The inner radius of the tube is $a = 0{,}5 \times 10^{-2}$ m, the outer radius, $b = 15{,}0 \times 10^{-2}$ m. Calculate the total resistance of the silicon between the inner and outer tubes.

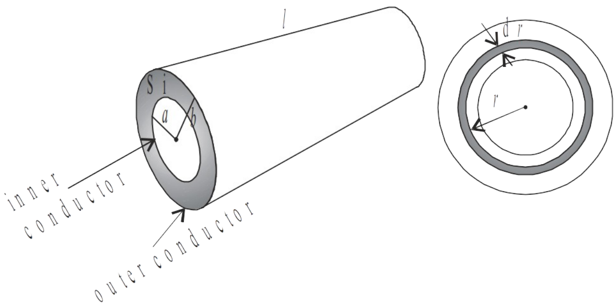

Fig. 7

16. A battery has an emf of 12 V and an internal resistance of 5×10^{-2} Ω. Its terminals are connected to a load resistance of 3 Ω.
    a) Find the current in the circuit and the terminal voltage of the battery.
    b) Calculate the power dissipated by the internal resistance of the battery and the power delivered by the battery.

17. A single loop circuit contains two external resistors and two sources of emf as is shown in Fig. 8. The internal resistances of the battery have been neglected.

a) Find the current in the circuit.

b) Calculate the power lost in each resistor.

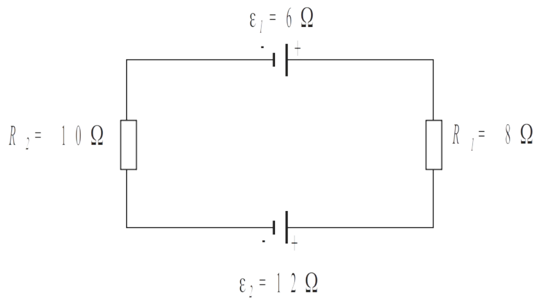

Fig. 8

18. The multiloop circuit contains three resistors, three batteries and one capacitor.

a) Find the unknown currents under steady-state conditions.

b) Calculate the charge on the capacitor. Situation is shown in Fig. 9.

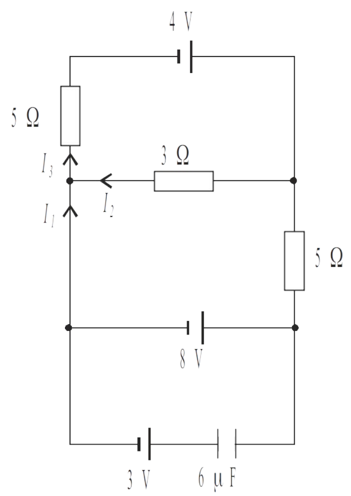

Fig. 9

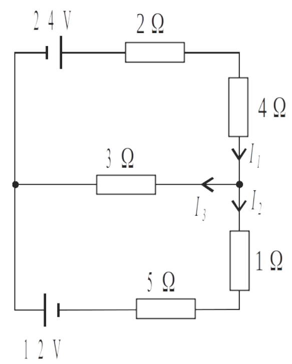

Fig. 10

19. Calculate each of the unknown currents I_1, I_2 and I_3 for the circuit drawn in Fig. 10.

20. A proton moves with a speed of 8×10^6 m/s along the *x*-axis. It enters a region where there is a field of magnitude 2.5 T, directed at an angle of 60° to the *x*-axis and lying in the *xy* plane (see Fig. 11). Calculate the initial magnetic force and acceleration of the proton.

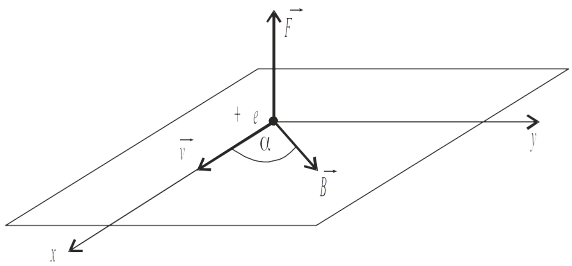

Fig. 11

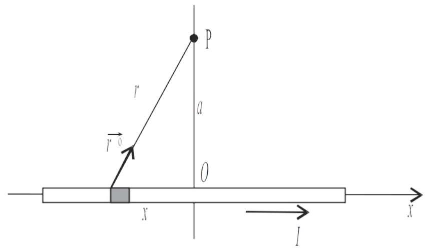

Fig. 12

21. A proton is moving in a circuit orbit of radius 14 cm in a uniform magnetic field of magnitude 0.35 T directed perpendicular to the velocity of the proton.
   a) Find the orbital speed of the proton if the mass of proton equals 1.67×10^{-27} kg.
   b) Calculate the radius of the electron that moves perpendicular to the same magnetic field and its speed equals the speed of the proton.
   c) Determine the sense of rotation for a proton and electron, too.

22. Consider a thin, straight wire carrying a constant current *I* and placed along the *x*-axis as is shown in Fig. 12. Let us calculate the total magnetic field at the point P located at a distance *a* from the wire.

23. Consider a circular loop of wire of radius R located in the yz plane and carrying a steady current I, as is shown in Fig. 13. Calculate the magnetic field at any axial point P at distance x from center of the loop.

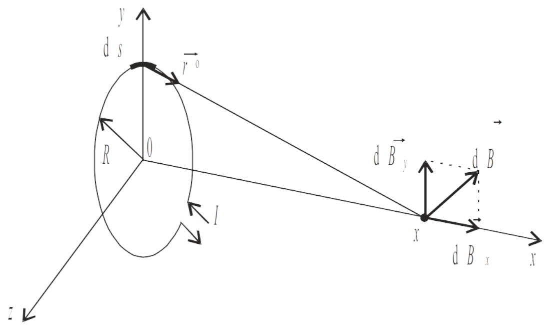

Fig. 13

24. A long, straight wire of radius R carries a steady current I_0 that is uniformly distributed through the cross section of the wire as is shown in Fig. 14. Calculate the magnetic field at a distance r from the center of the wire in the regions $r \geq R$ and $r < R$.

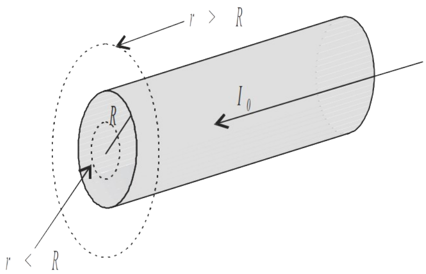

Fig. 14

25. Using Ampere`s law find the magnetic field inside an ideal solenoid of the length l and N turns carrying a current I.

26. A long straight wire oriented along the *y*-axis carries a steady current I_1 as is shown in Fig. 15. A rectangular circuit located to the right of the wire carries a current I_2. Find the magnetic force on the upper horizontal segment of the circuit that runs from $x = a$ to $x = a + b$.

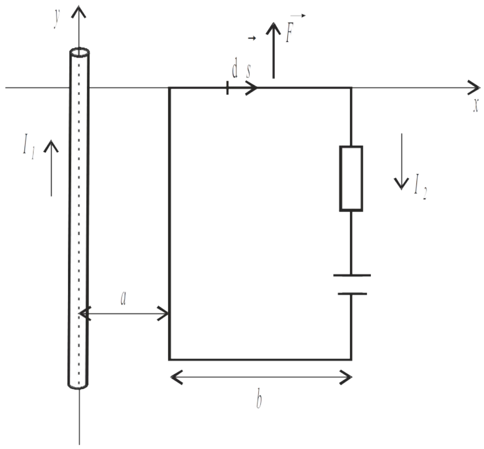

Fig. 15

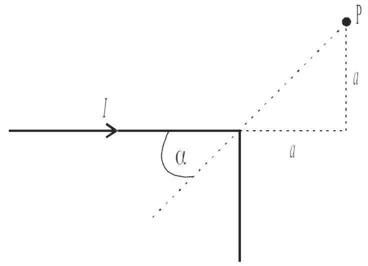

Fig. 16

27. What is magnetic induction B at the point P (see Fig. 16) if we assume that the current has the value of 15 A and the distance $a = 20\ \mathrm{cm}$.

28. A cyclotron is used to accelerate protons. The magnetic field has a flux density of $6.5 \times 10^{3}\ \mathrm{T}$. What must be frequency of the alternative potential difference of $2 \times 10^{4}\ \mathrm{V}$ if the mass of the proton is $1.67 \times 10^{-27}\ \mathrm{kg}$ and its charge is $+1.60 \times 10^{-19}\ \mathrm{C}$. (Note that the typical limit for protons for a typical cyclotron is about 25 MeV.)

29. A copper bar with length *l* is rotating with angular frequency ω at right angles to the uniform field B as is shown in Fig. 17. Calculate the emf , which is induced in the bar.

30. Suppose that rectangular loop having length *b* and width *a* of *N* turns is rotated at angular frequency ω in a uniform field B. The axis of the loop at right angles to the field as is shown in Fig. 18. What emf will be induced in this loop? (B is normal to the page.)

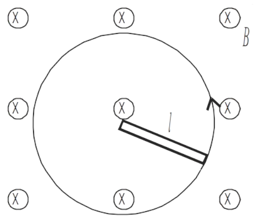

Fig. 17

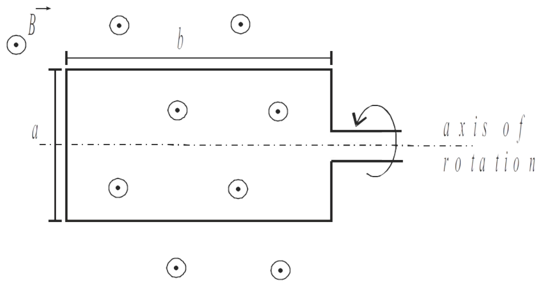

Fig. 18

31. A circular loop with radius 10 cm and $0.2\ \Omega$ resistance is placed in an essentially uniform field between two poles of an electromagnet, as is shown in Fig. 19. The magnetic field is increased at the rate 6×10^7 T/s . Determine

a) the current in the loop

b) the heat produced in the loop.

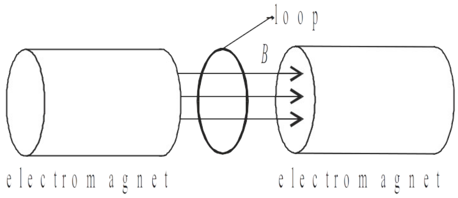

Fig. 19

32. Along straight wire and a rectangular wire frame lie on the plane *xy*. The side of the frame parallel to the wire is 30 cm long, the side perpendicular to the wire is 50 cm long. The currents are $I_1 = 10$ A and $I_2 = 20$ A .

a) What is the force on the loop?

b) What is the torque on the loop about straight wire as an axis?

c) Find the torque after the coil has been rotated 45° about the dashed axis on Fig. 20.

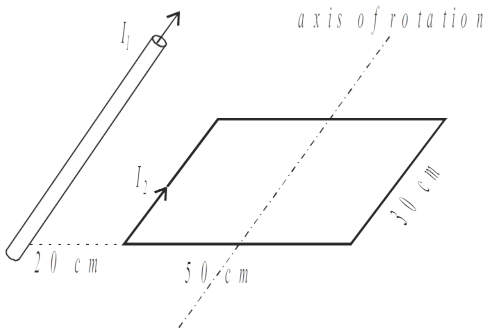

Fig. 20

33. Find the current density (assumed uniform) required in a horizontal aluminium wire to make in "float" in the earth`s magnetic field at the equator. The density of aluminium is $2.7\times10^3\ \mathrm{kg/m^3}$. Assume that the earth`s magnetic field is about 7×10^{-5} T and that the wire is oriented in the East-West direction.

34. A circular loop of wire with an area of $0.2\ \mathrm{m}^2$ and a resistance of $0.5\ \Omega$ is placed in a uniform magnetic field. How much variation must occur in B if $1.0\ \mathrm{C}$ of charge is to flow through the given point in the loop?

35. A sinusoidal wave traveling in the positive *x* direction has amplitude of 15 cm, wavelength of 40 cm and the frequency of 8 Hz. The displacement of the wave at $t=0\ \mathrm{s}$ and $x=0\ \mathrm{cm}$ is also 15 cm.

a) Find the wave number, period, angular frequency and phase velocity of the wave.

b) Determine the phase constant φ and write a general expression for the wave function.

36. Two waves traveling in opposite directions produced a standing wave. The individual wave function are given $y_1 = A_0 \sin(kx - 2t)$ and $y_2 = A_0 \sin(kx + 2t)$, where $A_0 = 4\ \mathrm{cm}$, $k = 3\ \mathrm{cm}^{-1}$.

a) Find the maximum displacement of motion.

b) Find the position of the nodes and antinodes.

37. Two waves traveling in opposite directions on a string fixed at $x = 0$ are described by the functions $y_1 = 0.2\sin(2x - 4t)$, $y_1 = 0.2\sin(2x + 4t)$.

a) Determine the function for the standing wave.

b) What is the amplitude at $x = 0.45\ \mathrm{m}$?

c) What is the other end fixed?

d) What is the maximum amplitude and where is its position?

38. A string of length 2 m and mass $4 \times 10^{-3}\ \mathrm{kg}$ is held horizontally, with one end fixed and a mass of 2 kg supported at the other end. Find the velocity of transverse waves in the string.

39. The amplitude of motion of the air during the passage of 1000 Hz sound wave of moderate loudness is about $5 \times 10^{-7}\ \mathrm{m}$. Calculate the wavelength of the sound and the maximum velocity and acceleration of the air due to the passage of the wave.

40. A steel wire having a diameter of 0.2 m is subject to a tension of 200 N. Determine the velocity of propagation of transverse waves along the wire.

41. A string having a normal length of 1 m and a mass of 0.2 kg is elongated of $4 \times 10^{-2}\ \mathrm{m}$ when it is stretched by a force of 10 N. Find the velocity of propagation of longitudinal waves along the string.

42. The left hand end of a long horizontal string oscillate transversally in simple harmonic motion with frequency $f = 250\,\text{Hz}$ and amplitude 2.6 cm. At $t = 0$ the end of the string is displaced outward 1.6 cm and is rising. The string is under a tension of 140 N and has linear density $\mu = 0.12\,\text{kg/m}^3$. State the equation for the travelling wave along the string.

43. A glass tube is open at one end closed at the other (by the movable piston). The tube is filled with $30\,^{\circ}\text{C}$ air, and 384 Hz turning forks is held at the open end. Resonance is heard when the piston is 22.8 cm from the open end and again when it is 68.3 cm from the open end.

a) What speed of sound is implied by these data?

b) Where would the piston be for the next resonance?

44. A 60 cm metal bar is clamped at one end is struck with the hammer. If the speed of longitudinal (compressional) waves in the bar is 4500 m/s.

a) What is the lowest frequency with which the struck bar is resonate?

b) What is the value of the classic modulus (Young`s modulus) if the density of the material of the bar is $\rho = 7.6 \times 10^3\ \text{kg.m}^{-3}$?

45. An ambulance travels down a highway at a speed of 33.5 m/s. Its siren emits sound at a frequency of 400 Hz. What is the frequency heard by a passenger in a car travelling at 24.6 m/s in the opposite direction as the car approaches the ambulance and as the car moves away from the ambulance?

46. A point source emits energy in the form of spherical waves. Let P_{av} be the average power output of the source. At a distance r from the source, the power is distributed over the surface area of a sphere $4\pi r^2$.

a) Find the intensity at a distance of 3 m from the source.

b) Find the distance at which the sound reduced to a level of 40 dB.

47. The amplitude of motion of the air during the passage of a 1000 Hz sound wave of moderate loudness is about 5×10^{-7} m. Calculate the wavelength of the sound and maximum velocity and acceleration of the air due to the passage of the wave.

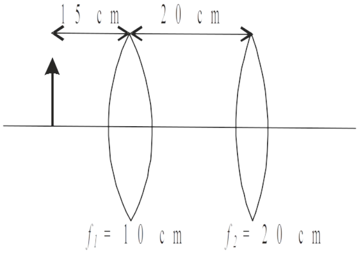

Fig. 21

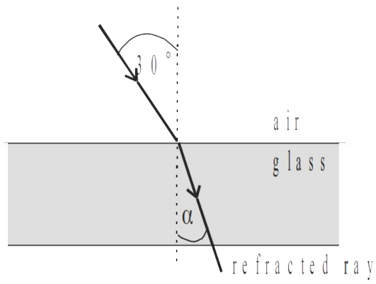

Fig. 22

48. Two thin lenses of local lengths 10 cm and 20 cm are separated by 20 cm, as is shown in Fig. 21. An object is placed 15 cm in front of the first lens. Find the position of the final image and the magnification of the system.

49. Light of wavelength 589 nm in vacuum passes through a piece of fused quartz with index of refraction $n = 1.458$.

a) Find the speed of light in quartz.

b) Determine the wavelength of this light in quartz.

50. A light ray produced by a sodium light (589 nm) travelling through air is incident on a smooth, flat slab of crown glass at an angle 30° to the normal, as is shown in Fig. 22. Find the angle of refraction.

51. The wavelength of red-helium-neon (HeNe) laser light in air is 632.8 nm. Determine

a) the frequency of light

b) the wavelength in a glass that has the index of refraction 1.5

c) the speed in glass.

52. An optical fiber is made of a clear plastic with index of refraction $n = 1.50$. For what angles with the surface light remain contained within the plastic "guide"?

53. A light source emits light of two wavelengths in the visible region, with $\lambda = 430\ \mathrm{nm}$ and $\lambda' = 510\ \mathrm{nm}$. The source is used in the double-split interference experiment in which $L = 1.5\ \mathrm{m}$ and $d = 0.025\ \mathrm{mm}$. Find the separation between the third-order bright fringes corresponding to these wavelengths.

54. Calculate the minimum thickness of a soap bubble film with $n = 1.33$ that will result in constructive interference in the reflected light if the film is illuminated with light whose wavelength in free space is 600 nm.

55. An oil film ($n = 1.45$) floating on water is illuminated by white light at normal incidence. The film is 280 nm thick. Find the dominant observed color in the reflected light.

56. What characteristic must a grating have in order to separate the two glow lines at $5.79 \times 10^{-7}\ \mathrm{nm}$ and $5.77 \times 10^{-7}\ \mathrm{nm}$ in the spectrum of mercury? The lines should be appear at an angle of 30° to the undeviated beam. What is the angular separation of the two lines?