Test 3

1.

Two point charges, q_1= +25 nC and q_2= -75 nC, are separated by a distance of 3 cm. Find the magnitude of electric force that q_1 exerts on q_2 .

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k=9·10^9 N·m^2·C^{-2}

q_1= +25 nC= +25·10^{-9} C

q_2= -75 nC= -75·10^{-9} C

r= 3 cm = 0.03 m

$F=k\cdot\frac{|q_1\cdot q_2|}{r^2}= 9\cdot10^9\cdot\frac{|25\cdot10^{-9}\cdot75\cdot10^{-9}|}{0.03^2}\approx 0.019$ (N)

2.

A positive point charge q= +3 μC is surrounded by a sphere with radius r = 0.2 m. Find the electric flux Φ (N·m^2·C^{-1}) through the sphere.

*****

k=9·10^9 N·m^2·C^{-2}

q= +3 μC = +3·10^{-6} C

$\Phi = \frac{q}{\epsilon_0} = 4\cdot\pi\cdot k\cdot q \approx 4\cdot3.14\cdot9\cdot10^9\cdot3\cdot10^{-6} = 3.4\cdot10^5$ (N·m^2·C^{-1})

3.

A parallel-plate capacitor (insulator is air) has a capacitance of C = 1 F. If the plates are 1 mm apart, what is the area A (m^2) of the plates?

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d = 1 mm = 1·10^{-3} m

$A = \frac{C\cdot d}{\epsilon_0} = 4\cdot\pi\cdot k\cdot C\cdot d = 4\cdot3.14\cdot9\cdot10^9\cdot1\cdot1\cdot10^{-3} = 1\cdot10^8$ (m^2)

4.

Find the equivalent capacitance,
when the two capacitors C_1 = 1 F and C_2 = 3 F are connected in series.

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$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{1} + \frac{1}{3} = \frac{4}{3}$

$C = \frac{3}{4} = 0.75$ (F)

5.
Find the equivalent capacitance,
when the two capacitors C_1 = 1 F and C_2 = 3 F are connected in parallel.
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$C = C_1 + C_2 = 1 + 3 = 4$ (F)

6.
The potential difference is V = 2 V.
A current is I = 0.5 A.
Find the resistance R (Ω).
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$R = \frac{V}{I} = \frac{2}{0.5} = 4$ (Ω)

7.
A wire has a diameter of d = 1 mm, the length l = 314 m, and the resistivity $\rho = 2\cdot10^{-8}$ Ω·m.
Find the resistance R (Ω).
*****

$d = 1$ mm $= 10^{-3}$ m
$R = \rho\cdot\frac{l}{A} = \rho\cdot\frac{l}{\pi\cdot\frac{d^2}{4}} = 2\cdot10^{-8}\cdot\frac{314}{3.14\cdot\frac{(10^{-3})^2}{4}} \approx 8$ (Ω)

8.
Find the equivalent resistance,
when the two resistors R_1 = 1 Ω and R_2 = 3 Ω are connected in parallel.
*****

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{1} + \frac{1}{3} = \frac{4}{3}$
$R = \frac{3}{4} = 0.75$ (Ω)

9.
Find the equivalent resistance,
when the two resistors R_1 = 1 Ω and R_2 = 3 Ω are connected in series.
*****

$R = R_1 + R_2 = 1 + 3 = 4$ (Ω)

10.
Find the power of energy dissipation P (W) in the resistor R = 10 Ω, if current I = 2 A.
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$P = I^2\cdot R = 2^2\cdot10 = 40$ (W)

11.
The proton ($q = 1.6 \cdot 10^{-19}$ C) has velocity $\upsilon = 2 \cdot 10^5$ m/s.
The uniform magnetic field with magnitude $B = 5$ T has angle with velocity direction $\alpha = 30°$.
Find Lorentz force F (N).
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sin(30°) = 0.5
$F = q \cdot \upsilon \cdot B \cdot \sin(\alpha) = 1.6 \cdot 10^{-19} \cdot 2 \cdot 10^5 \cdot 5 \cdot 0.5 = 8 \cdot 10^{-14}$ (N)

12.
Two straight, parallel, superconducting cables 4.5 mm apart carry equal currents of $I = 15000$ A.
Length of cables is $l = 1$ m.
Find force F (N) of interaction between these cables.
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$\mu_0 = 4 \cdot \pi \cdot 10^{-7}$ ($T \cdot m \cdot A^{-1}$)
$r = 4.5$ mm $= 4.5 \cdot 10^{-3}$ m
$F = \frac{\mu_0 \cdot I_1 \cdot I_2 \cdot l}{2 \cdot \pi \cdot r} = \frac{4 \cdot \pi \cdot 10^{-7} \cdot 15000 \cdot 15000 \cdot 1}{2 \cdot \pi \cdot 4.5 \cdot 10^{-3}} = 1 \cdot 10^4$ (N)

13.
The solenoid consists of a helical winding of wire on a cylinder,
usually circular in cross section.
The solenoid has $n = 10^7$ turns of wire per meter of length and carries a current $I = 2$ A.
Find the magnitude of magnetic field B (T) at the center of the solenoid's length.
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$\mu_0 = 4 \cdot \pi \cdot 10^{-7}$ ($T \cdot m \cdot A^{-1}$)
$B = \mu_0 \cdot n \cdot I = 4 \cdot \pi \cdot 10^{-7} \cdot 10^7 \cdot 2 = 25.12$ (T)

14.
The speed of sound at 20 °C is $\upsilon = 344$ m/s.
The frequency is $f = 172$ Hz.
Find the wavelength λ (m).
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$\lambda = \upsilon / f = 344/172 = 2$ (m)

15.
The frequency of wave is $f = 500$ Hz.
Find the period T (s).
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$T = 1/f = 1/500 = 0.002$ (s)