March 4, 2004, Instructor Yu. Kamyshkov

Test #2 Class P222 SOLUTIONS

(each problem is 20 point. 100 points =100%)

① Which of the following are correct units for (correct are in red, crossed are non-correct)

(a) capacitance: ~~C·V~~ ; μF ; ~~V^2/J~~ ; C^2/J

(b) magnetic flux: T·m^2 ; V·s ; Wb ; ~~G(Gauss)~~

(c) magnetic filed: ~~V·m/A~~ ; ~~N·A/m~~ ; N/(A·m) ; T(Tesla)

② 50-km long power transmission line has a total resistance of 0.6 Ω. A generator produces 150 V at 70 A. In order to reduce energy loss due to heating of the transmission line, the voltage is stepped up with a transformer with turns ratio of $N_s : N_p$ = 100 : 1. What percentage of the original energy is lost due to transmission loss when the transformer is used? Compare it with energy loss if transformer is not used.

Without the transformer produced power is P=V·I=150V·70A=10.5 kW. With step up transformer 100:1 the transmission voltage is increased by factor of 100 but produced power should remain the same. That means that generator with transformer produces the same power (assuming there is no substantial losses in the transformer) of 10.5 kW but with voltage 15,000V at current 70/100=0.7A. Heating losses in the transmission wire can be found as
$\Delta P = I^2 \cdot r$, where r = 0.6 Ω.
(a) Without transformer heating losses are $\Delta P = (70A)^2 \cdot 0.6\ \Omega = 2.94$ kW,
or 2.94kW·100% / 10.5kW = 28 %
(b) With transformer $\Delta P = (0.7A)^2 \cdot 0.6\ \Omega = 0.294$ W or 0.294W·100%/10,500W = 0.0028 %

③ A 400-W computer (processor plus monitor) is turned on 8.0 hours per day. If electricity costs 8 cents per kilowatt-hour, how much does it cost to run the computer annually?

Energy consumed by computer per day is 0.4kW × 8h = 3.2 kW-h / day. With cost 8 cents per kW-h for a year of operation total cost will be
Cost = 3.2 kW-h / day × 365 days / year × 0.08 $ / kW-h = 93.44 $ / year.

④ The coil of a generator has 50 loops (turns) and a cross-sectional area of 0.25 m^2. What is the maximum emf generated by this generator if it is spinning with an angular velocity of 4 rad/s in a 2.0 T magnetic filed?

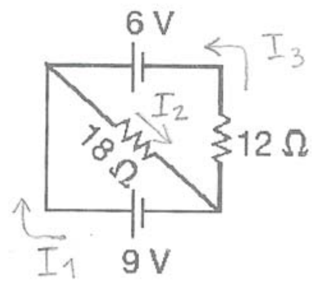
$\mathcal{E} = N \times A \times B \times \omega \times \sin\theta$; $\mathcal{E}_{max} = N \times A \times B \times \omega$
Max *emf* = 50 turns × 0.25 m^2 × 2 T × 4 rad/sec = 100 V

⑤ A coil lies flat on a horizontal tabletop in a region where the magnetic field points straight down. The magnetic field disappears suddenly. When viewed from above, what is the direction of the induced current in this coil as the field disappears.

Clockwise looking from the top

⑥

What current flows in the 12-Ω resistor? What is direction of this current?



Let's assign the directions of currents in the circuit as shown in the figure.

From Kirchhoff's node rule: $I_1 + I_3 = I_2$ (1)

From Kirchhoff's loop rule: $18 \cdot I_2 - 9V = 0$ (2) for lower loop

$18 \cdot I_2 + 12 \cdot I_3 - 6V = 0$ (3) for upper loop

Solving system (1), (2), (3) of linear equations:

(substituting (1) into (2) and (3) etc.) we get:

$-12 \cdot I_3 = 3$ V or $I_3 = -0.25$ A

Minus sign means that the initially assigned direction of current I_3 through 12-Ω resistor should be reversed.