January 10, 2025 Student – name (Block capitals, please):

Theory	Task1	Task2	Task3	AddOns	Result

1. Coulomb's law.

2. Ohm's law – both [integral and differential] notations

3. Four [main] Maxwell equations:

4. Static definitions of self- and mutual inductance:

5. Skin depth as a function of frequency and material properties :

6. Boundary conditions for **E**, **D** – interface between two dielectrics – tangential components:

7. Biot-Savart's law:

8. Wave equation for **E**:

9. Wave impedance of TE modes in a metallic waveguide given as a function of frequency:

10. Poynting theorem:

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TASK 1:

Two metallic balls are placed in vacuum at the distance of 2 m, carrying charges +Q and –Q. Radii of both balls are equal to 10 mm. Electrostatic force attracting the balls is 1 μN. Find out:

a) Charge Q (4p)

b) Location of the maxima of Electric field strength (3p)

c) The field strength in the middle of the structure (eg. between the balls) (3p)

Results:

a)	b)	c)

TASK 2:

Current I = 1 kA is fed to the load through a line composed of two wires of circular crossection. Diameter of each of these conductors is equal to 15 mm and the spacing between these conductors is 2 m. Both conductors are made of copper (σ = 57 000 000 S/m) The line is 1 km long, loaded by a resistor R = 2 Ω. Find out:

d) Current density within the conductors (2p)

e) Force (caused by the currents) that affects conductors (4p)

f) Voltage at the input of the line (4p)

Results:

d)	e)	f)

TASK 3:

An electromagnetic wave, propagating from a distant source in the direction of z. At z = 0 it carries average power of 1kW per square meter, through a partially conductive material. The wave frequency is equal to 2.45 GHz, material properties: σ = 2 S/m, ε_r = 42, $\mu = \mu_0$.
Specify:

g) The distance z_1, where the average power density falls down to 10 W per square meter **(7p).**

h) Wavelength of the wave within this material. **(3p).**

Results:

g)	h)

ε_0 = 8.854 pF/m, $\mu_0 = 400\pi$ nH/m