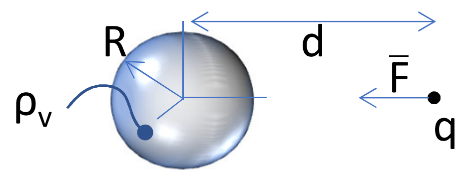
POLITECNICO MILANO 1863	094784 **Fund. of Electromagnetic Fields**	Date: ________________________
	Last Name:____________________	First Name: ___________________
	Personal code ("Persona"): ________________________________	Signature: ______________________________

02 Jan 2023 TEST EXAM (OPTIONAL)

Please answer the following questions/problems, providing a meaningful explanation of the steps/computations involved. Please specify units for all numeric results requiring them, otherwise those results will be considered wrong. Allowed support material: books, notes, scientific calculator.

Exercise 1a (alternative to exercise 1b) [8 points]

In vacuum, a uniform volumetric charge density ρ_v=1.2 · 10^{-3}C/m^3 fills a spherical volume of radius R. Due to this distribution, a point charge q=-0.03C, located outside the sphere at a distance d=10cm from its center, is subject to a force F=35kN toward the center of the sphere.



1. Compute the radius R of the sphere.
2. Compute the total electric field (due to sphere and point charge) at the center of the sphere

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Exercise 1b (alternative to exercise 1a) [8 points]

A bifilar line is made by two parallel wires both with radius a=1mm in a uniform medium with ε_r=6 and unknown μ_r and has an inductance per unit length of L_{pul}=2.47µH/m and each wire carries a DC current denoted as I (in opposite directions).
Under a quasistatic-approximation, the characteristic impedance of the line is known to be Z_c=200Ω.

- Compute the distance d between the two wires and μ_r.

Hint: one wire contributes to the to the total flux per unit length of the bifilar line approximately by $\mu_0\mu_r\frac{I}{2\,\pi}\ln(\frac{d}{a})$

Hint: the capacitance per unit length for the bifilar line has the approximate expression:

$$C_{pul} = \epsilon_0\epsilon_r\frac{\pi}{\ln(\frac{d}{a})}$$

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Exercise 3 [12 pt]

A plane wave has electric field in time-domain given by:

$$\bar{\mathcal{E}}\,(t) = 3\frac{V}{m}\,\hat{\imath}_x \cos\left(\omega t - \frac{32}{m}z - \frac{\pi}{4}\right)\mathrm{e}^{-\frac{0.05}{m}z}$$

travelling in a good dielectric medium with ε_r'=2.5 and μ_r=1 and no conductivity (σ_1=0)

1. What is the frequency? What is the propagation direction? What is the wavelength?
2. What is the loss tangent of the dielectric (tan delta)?
3. Compute the phasor of the reflected electric field in z=0 if the wave above hits a perfect electric conductor (PEC) in z=0 (the normal of the conductor is along $\hat{\imath}_z$)
4. Compute the reflection coefficient instead if the wave above hits a good conductor with ε_r'=1, μ_r=1, $\sigma=4\cdot10^2$ S/m in z=0 (the normal of the conductor is along $\hat{\imath}_z$)

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Exercise 4 [12 pt]

A transmission line with the following equivalent parameters per unit length R=1Ohm/m, L=150nH/m, C=60pF/m, G=0.002S/m is terminated on a load impedance Z_L=(25-j10)Ohm. The transmission line is L=0.5m long and it must transport a signal at f=1.5GHz.

1. Compute the characteristic impedance Z_0, the attenuation constant of the transmission line α in dB/m, the phase constant β in rad/m (approximations for low loss can be used) and the wavelength λ in the transmission line
2. What is the input impedance Z_{in}, looking toward the load into the line?
3. How much real power is delivered by a generator with amplitude Vg=10V and internal impedance 50Ohm to the input of the line? How much real power is dissipated by the load?