BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
FIRST SEMESTER 2022-23
EEE/INSTR/ECE F212 ELECTROMAGNETIC THEORY
MID SEMESTER TEST (CLOSED BOOK)

Date : 04/11/2022 **Duration : 90 Minutes** **Max marks : 60**

Name :	ID :	Tut sec :

Instruction: Answers should be presented in a clear and legible manner, to be considered for evaluation

1A) Two conducting spherical shells with radii a=3 cm and b=6 cm are placed concentrically. The dielectric in the interior region is $\varepsilon_r = 1$ for $0< \phi < \pi/2$ and $\varepsilon_r = 8$ for the remaining space. Assume $+Q$ coulombs is placed on the inner sphere. Start with Gauss's law to find out the capacitance of the shell. **[10 M]**

1B) If $\boldsymbol{F} = r\cos(\phi)\,\boldsymbol{a_r} + \sin(\phi)\,\boldsymbol{a_\phi}$, verify Stoke's theorem for the surface S enclosed by path a-b-c-d-a shown in **Fig.1**. **[10 M]**

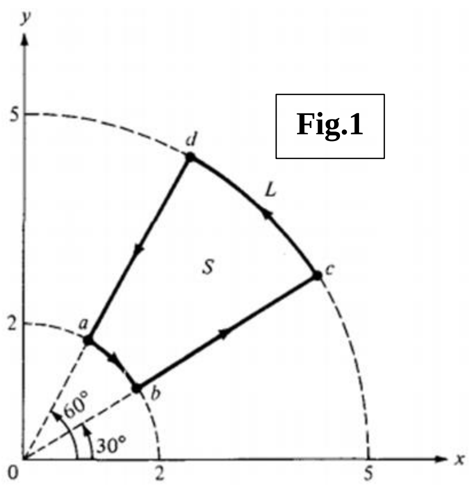

Fig.1

2A) An infinite line charge of ρ_L=40 nC/m lies at location x=6 m, y=3 m in freespace. (a) What is the electric field intensity at $P(x,y,z)$? Now suppose an infinite, perfectly conducting plane is placed at x=4 m, and is grounded. (b) What is the electric field intensity at location $P(7, -1, 5)$ m due to the line charge in the presence of the ground plane? **[10 M]**

2B) A parallel-plate capacitor has its conducting plates kept at $x = 0$ and d. The space between the plates is filled with an inhomogeneous material with permittivity profile, $\varepsilon = \varepsilon_0\,(1+x/d)$. The plate at $x = d$ is maintained at V_0 while the plate at $x = 0$ is grounded. Solve *Laplace's equation* for this boundary value problem to obtain the distributions of the (a) Potential, V (b) Electric field, $\boldsymbol{E}$ and (c) Polarization vector, $\boldsymbol{P}$, between the plates, (d) and finally the surface charge density, ρ_s on the inner face of the upper plate. **[10 M]**

3A) For a transmission line, the primary constants are 0.8 Ω/m, 0.3 μH/m, 75 pF/m and 0.01 S/m. The line is operating at the sinusoidal frequency of 10 MHz. For this line, find the (a) Characteristic impedance (b) Propagation constant (c) Phase velocity (d) Test if this line is distortionless. **[8 M]**

3B) Fig. 2 shows a transmission line (TL) network containing two junctions J1 and J2. As shown, at J1 TL-1 and TL-2 are joined to TL-3. Given that TL-1 and TL-2 are identical in terms of characteristic impedance (75 Ω) and length. TL-1 is short-circuited and TL-2 is open-circuited as shown. If the short-circuited input impedance of TL-1 (when disconnected from rest of the network) is j25 Ω, find the (a) Input impedance (Z_{in1}) seen from the left of junction J1 (b) Reflection coefficient presented to the left of the junction J1 if TL-3 has 100 Ω impedance and λ/4 m length

In continuation, **Fig.2** also shows that at junction J2, TL-3 (100 Ω, λ/4 m) and TL-4 (100 Ω, λ/2 m) are joined to TL-5 (50 Ω, λ/5 m). Find the (c) Input impedance (Z_{in2}) seen from the left of junction J2 (d) Reflection coefficient presented to the left of the junction J2 (e) Overall input impedance of the network (Z_{in3}). **[12 M]**

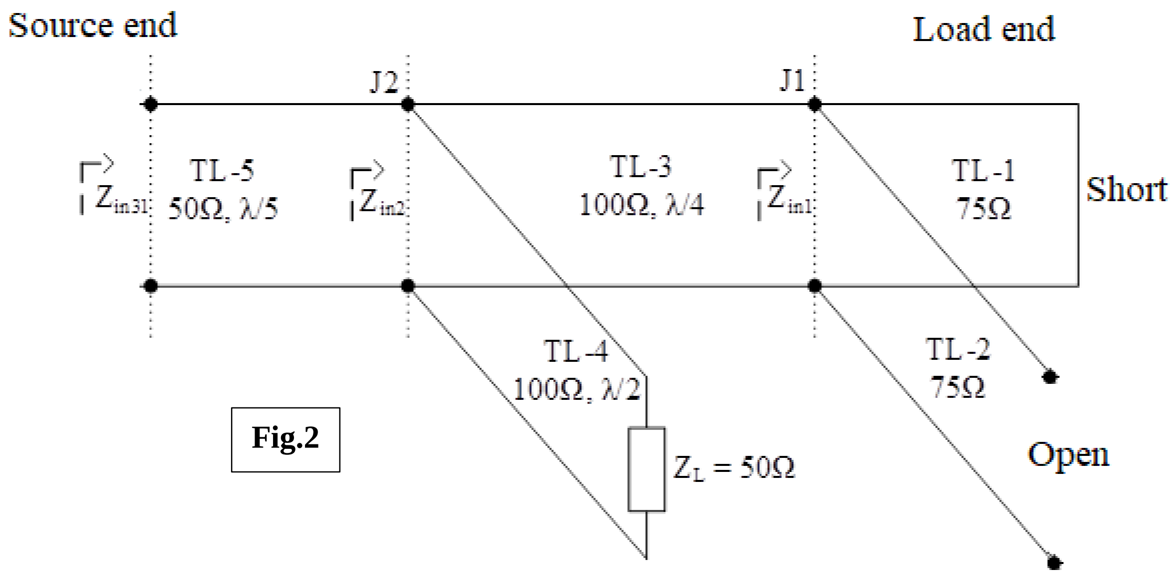

Fig.2

END