# UNIVERSITY OF LONDON

## B.Sc. (ENGINEERING) EXAMINATION 1962

### PART I

**for Internal and External Students**

### (7) APPLIED ELECTRICITY

Friday, 22 June: 2.30 to 5.30

*Attempt SIX questions only.*

$\mu_0 = 4\pi \times 10^{-7}$ H/m. $\varepsilon_0 = 8{\cdot}85 \times 10^{-12}$ F/m.

**1.** A parallel-plate capacitor has two electrodes, each having an area of 100 $cm^2$, spaced 4 mm apart. A sheet of dielectric, 1·5 mm thick having a relative permittivity of 4, is placed on each electrode, completely covering it and leaving an air space of 1 mm between the two sheets. Calculate the capacitance of the capacitor so formed, deriving any formula used and stating any assumption made. Calculate also the maximum voltage which can be applied between the electrodes if the potential gradient in the air is not to exceed 20 kV/cm.

**2.** A coil uniformly wound on an iron ring is designed to have an inductance of 10 H. The ring has a radial air gap, 1 mm wide, and the mean length of the remaining flux path is 25 cm. The cross-sectional area of the core is 7 $cm^2$. Neglect flux fringing and leakage. Assuming the relative permeability of the core at working flux density to be 4800, determine the number of turns required in the coil.

**3.** A voltmeter connected across a resistor of $R$ ohms indicates $V$ volts when an ammeter connected to measure the total current indicates $I$ amperes. If the ratio $V/I$ is denoted by $R_1$ and the voltmeter current is $i$, determine the ratio $i/I$ in terms of $R$ and $R_1$.

If $R$ is 50 Ω, and the ammeter and voltmeter have resistances of 0·2 Ω and 1000 Ω respectively, determine, as a percentage of $R$, the difference between $R_1$ and $R$.

Show how this difference could be reduced by rearrangement of the instrument connections and determine the percentage difference for the new arrangement.

**4.** A 1-$\mu$F loss-free capacitor and a 100-Ω non-reactive resistor are connected in series across a 100-V, 2000-c/s supply. Two 40-Ω non-reactive resistors in series are also connected across the same supply. Determine the total supply current and draw a vector diagram for the voltages and currents in the circuit.

Determine, graphically or otherwise, the magnitude of the voltage between the junction of the two 40-Ω resistors and the junction of the capacitor and resistor in the other branch.

**Turn over**

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**5.** Draw a circuit diagram showing how two wattmeters may be connected to read the total power in a 3-phase, 3-wire circuit. Draw the vector diagram and deduce an expression for the reading of each wattmeter if the load is balanced and the power factor is *leading*.

The input power to a 10-hp, 400-V, 3-phase motor is measured by two wattmeters. Determine the line current and the reading of each wattmeter when the motor is operating on full load with an efficiency of 85 per cent and at a power factor of 0·78 leading.

**6.** Describe the essential features of the construction of a single-phase transformer, and explain its operation.

A single-phase transformer has a primary winding of 200 turns and the secondary winding of 90 turns is connected to a 15-Ω non-reactive resistor. Determine the primary current and power factor when the transformer is connected to a 230-V, 50-c/s supply. The magnetising current is 0·8 A; the iron loss and all voltage drops may be neglected.

Sketch and explain the vector diagram for the transformer when operating under the above conditions.

**7.** Derive an expression for the r.m.s. value of the e.m.f. generated in a single-turn full-pitched coil in the stator of an alternator, the flux distribution in which is sinusoidal over each pole pitch.

An alternator winding consists of $n$ full-pitched coils connected in series and accommodated in $2n$ slots equally spaced around the stator periphery. Explain why the total e.m.f. of the distributed winding is less than $n$ times the e.m.f. per coil.

A 16-pole alternator having 144 stator slots is driven at 450 rev/min. The flux per pole is 0·05 Wb. One full-pitched turn is connected in series with a similar turn which has its conductors in the slots next to those containing the conductors of the first turn. Calculate the magnitude and frequency of the resultant e.m.f. for these two turns.

**8.** Derive an expression for the e.m.f. induced in the armature winding of a d.c. generator in terms of the flux per pole, the speed of rotation, etc.

A 4-pole, 1000-rev/min, shunt-excited generator having a wave-wound armature with 846 conductors gives an output of 20 kW at 460 V. The resistances of the armature and field circuits are 0·45 Ω and 260 Ω respectively.

Calculate (*a*) the flux per pole, (*b*) the torque in newton-metres required to drive the armature if the friction, windage and iron losses are 750 W.

**9.** Describe, with the aid of sketches, the main constructional features of an electrodynamic (dynamometer) wattmeter. State its principle of action, and explain why, when connected in a single-phase alternating current circuit, the instrument indicates power.

**10.** An electron has a velocity $v$ metres/second perpendicular to the direction of a magnetic field of density $B$ webers/metre$^2$. Derive an expression for the transverse force on the electron.

A direct voltage of 50 V is maintained between two parallel metal plates, spaced 1 cm apart in an evacuated tube. There is a uniform magnetic field at right angles to the electric field, extending the whole length of the plates. An electron, travelling at $30 \times 10^6$ m/s, enters the space between the plates in a direction perpendicular to the electric and magnetic fields. If the electron is not deflected, calculate the density of the magnetic field.

What potential difference would be required to accelerate the electron from rest to the above velocity? The ratio of charge/mass for an electron is $1{\cdot}76 \times 10^{11}$ coulombs/kilogramme.

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