(a) A 250 kVA transformer has 500 turns on the primary and 100 turns on the secondary. The primary and secondary resistances are 0.45 Ω and 0.035 Ω respectively, and the corresponding leakage reactances are 1.15 Ω and 0.045 Ω respectively. The supply voltage is 3.3 kV. Calculate the following:
   i. Equivalent resistance and reactance referred to the primary and secondary sides
   ii. Voltage regulation for full-load having power factor of 0.85 lagging
   iii. Open-circuit and short-circuit tests performed on this transformer gave measured power values of 1400 W and 1850 W respectively. Determine the efficiency for a 0.88 lagging power factor load.

(b) Mention any THREE types of losses that occur in a transformer.

(c) Give TWO main purposes of transformer coolant.

(d) Briefly explain the following transformer cooling methods:
   i. ONAN
   ii. ONAF
   iii. OFAF

(e) Give any TWO advantages of oil over air as a transformer cooling agent

(a) State THREE methods of DC motor speed control.

(b) State the THREE main factors that account for the higher rate of decrease in terminal voltage of the shunt generator.

(c) Sketch and label the speed-load and torque-load characteristics of a shunt motor.

(d) Using the speed equation, explain what will happen when there is a break in the excitation circuit of the shunt motor

(e) The armature of a DC machine has a resistance of 0.35 Ω and is connected to a 400 V supply. Calculate the e.m.f. generated when it is running:
   (i) as generator supplying 120 A load
   (ii) as a motor taking 100 A current

(f) An 8-pole 50 Hz squirrel-cage motor has full-load speed of 900 rpm. What is the percent slip at full-load?

(a) What is an electromechanical energy conversion device?

(b) Give the energy balance equation for an electromechanical energy conversion system

(c) A U-shaped electromagnet having **three (3)** air-gaps has a core of effective length 750 mm and a cross-sectional area of 600 mm^2. A rectangular block of steel of mass 7.5 kg is attracted by the electromagnet's force of alignment when its 600-turn coils are energized. The magnetic circuit is 200 mm long and the effective cross-sectional area is also 650 mm^2. If the relative permeability of both core and steel block is 880, estimate the coil current. Neglect frictional losses and assume the acceleration due to gravity as $g = 10\, ms^{-2}$. (HINT – for 2 air gaps it is $2B^2A/2\mu_o$, for 3 air gaps it is $3B^2A/2\mu_o$).