1. A 200 V, 20 A, 900 rpm separately excited DC motor is having an armature resistance of 1 ohm, and its field voltage rating is 100 V. (1+1 marks)
   a. Determine the back-emf of the motor when it is delivering the rated load, i.e. armature current = 20 A, and rotor speed is 900 rpm.
   b. If the load is reduced such that the armature current is 10 A, and field voltage is also reduced to 85 volt, what will be the speed of the motor? (Hint: Assume that the field flux is directly proportional to the field voltage)

2. An induction motor connected to a 50 Hz supply rotates at 485 rpm. (0.5+0.5+1 marks)
   a. What is the speed of rotation (in rpm) of the stator magnetic field with respect to the rotor?
   b. What is speed of rotation (in rpm) of rotor magnetic field with respect to the rotor, in rpm?
   c. What is the speed of rotation (in rpm) of stator magnetic field with respect to the rotor magnetic field? Give justification. Credit will be given only if the justification is correct.

3. A buck-converter is used to converter input voltage of V_i volt to output of V_o. Current through its inductor 'L' is shown below. Notice that the inductor current is zero for 'kT' duration. (0.5 + 1.5 marks)
   a. Plot the waveform of voltage across the inductor in terms of V_i and V_o.
   b. Obtain the expression for the gain V_o/V_i in terms of D, k, and T
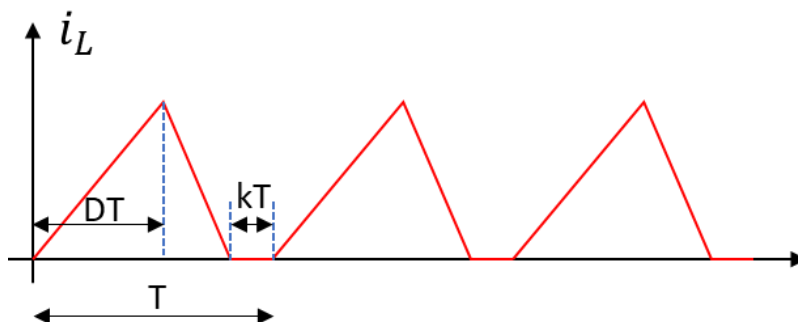
4. Three winding layouts are shown in following figure. Name their types in terms of nature and number of layers. (1.5 mark)

(a)   (b)   (c)
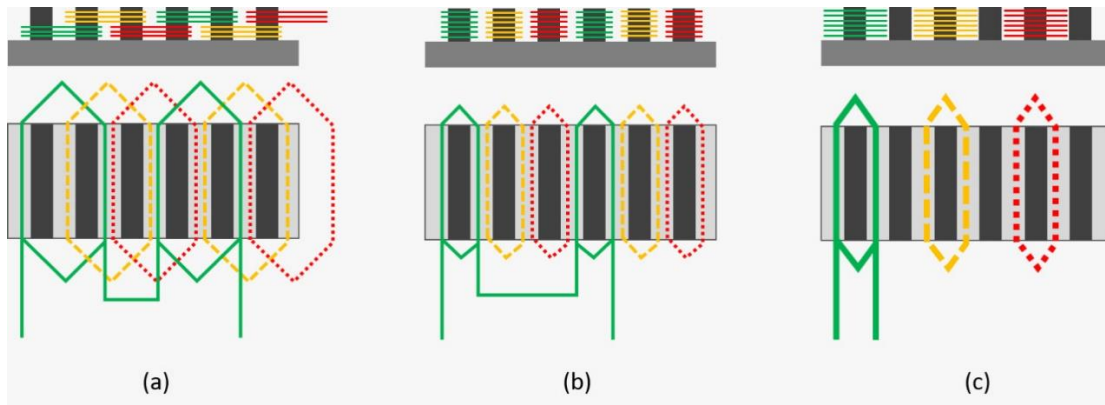
5. The MMF distribution due to a concentrated winding was shown to you in the class. Following figures show the resultant field distribution in the airgap for different time instances when sinusoidal currents of 50 Hz are fed to three-phase concentrated windings. The dominant components (f1, f5, and f7) of the resultant field are also shown. (1.5 + 1 marks)

   a. Now, it is decided to use permanent magnet based rotor for this machine. State which pole numbers are suitable for such a machine.

   b. Assume that fundamental component (f1) is rotating in clockwise direction. State the direction of rotation of rotor for all the pole numbers you have found.

(a) t = 0 ms

(b) t = 2.5 ms

(c) t = 5 ms

(d) t = 7.5 ms