TUTORIAL 5 Inductance and Magnetic Fields

- **5.1** Explain what is meant by a magnetomotive force (m.m.f.).
- **5.2** Describe the field produced by a current flowing in a straight wire.
- **5.3** A straight wire carries a current of 3 A. What is the magnetic field at a distance of 1 m from the wire? What is the direction of this field?
- **5.4** What factors determine the flux density at a particular point in space adjacent to a current-carrying wire?
- **5.5** Explain what is meant by the permeability of free space. What are its value and units?
- **5.6** Explain what is meant by relative permeability. What are its value and units? What would be typical values for this quantity for non-magnetic and ferromagnetic materials?
- **5.7** Give an expression for the magnetomotive force produced by a coil of *N* turns that is passing a current of *I* amperes.
- **5.8** A coil is formed by wrapping wire around a wooden toroid. The cross-sectional area of the coil is 400 mm², the number of turns is 600, and the mean circumference of the toroid is 900 mm. If the current in the coil is 5 A, calculate the magnetomotive force, the magnetic field strength in the coil, the flux density in the coil and the total flux.
- **5.9** If the toroid in Exercise 5.8 were to be replaced by a ferromagnetic toroid with a relative permeability of 500, what effect would this have on the values calculated?

- **5.10** If an m.m.f. of 15 ampere-turns produces a total flux of 5 mWb, what is the reluctance of the magnetic circuit?
- **5.11** State Faraday's law and Lenz's law.
- **5.12** Explain what is meant by inductance.
- **5.13** Explain what is meant by self-inductance.
- **5.14** How is the voltage induced in a conductor related to the rate of change of the current within it?
- **5.15** Define the henry as it applies to the measurement of self-inductance.
- **5.16** The current in an inductor changes at a constant rate of 50 mA/s, and there is a voltage across it of 150 μ V. What is its inductance?
- **5.17** Why does the presence of a ferromagnetic core increase the inductance of an inductor?
- **5.18** Calculate the inductance of a helical, air-filled coil 500 mm in length, with a cross-sectional area of 40 mm² and having 600 turns.
- 5.19 Calculate the inductance of a coil wound on a ferromagnetic toroid of 300 mm mean circumference and 100 mm² cross-sectional area, if there are 250 turns on the coil and the relative permeability of the toroid is 800.
- **5.20** How does a real inductor differ from an ideal component?
- **5.21** Why do all conductors introduce amounts of stray inductance into circuits?
- **5.22** Calculate the effective inductance of the following arrangements.



- **5.23** Describe the relationship between voltage and current in an inductor.
- **5.24** A constant current of 3 A is passed through a 12 H inductor. What voltage will be produced across the component?
- **5.25** Why is it not possible for the current in an inductor to change instantaneously?

- **5.26** Explain what is meant by a time constant. What is the time constant of a series LR circuit with $R = 50\Omega$ and L = 100 mH?.
- **5.27** If the resistor in Exercise 5.26 is increased by a factor of 10, to 500 Ω , what value of inductor would be required to leave the time constant of the circuit unchanged?
- **5.28** Discuss the implications of induced voltages when switching inductive circuits.
- **5.29** What is the relationship between the sinusoidal current in an inductor and the voltage across it?
- **5.30** What is the energy stored in an inductor of 2 mH when a current of 7 A is passing through it?
- **5.31** Explain what is meant by mutual inductance.
- **5.32** Define the henry as it applies to the measurement of mutual inductance.
- **5.33** What is meant by a coupling coefficient?
- **5.34** What is meant by the turns ratio of a transformer?
- **5.35** A transformer has a turns ratio of 10. A sinusoidal voltage of 5 V peak is applied to the primary coil, with the secondary coil open circuit. What voltage would you expect to appear across the secondary coil?
- **5.36** What would be the effect of adding a resistor across the secondary coil of the transformer in the arrangement described in Exercise 5.35?
- **5.37** What is meant by a step-up transformer?
- **5.38** What is meant by a step-down transformer?
- **5.39** Explain the dot notation used when representing transformers in circuit diagrams.
- **5.40** Describe the operation of an inductive proximity sensor.
- **5.41** Describe the construction and operation of an LVDT.