5. The pick-up on an electric guitar produces an electrical signal from the vibrations of the guitar strings. The pick-up consists of a small coil of insulated wire wound round a small cylindrical magnet as illustrated in Fig. 5.1.

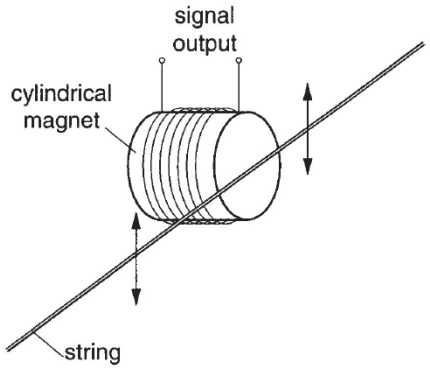

Fig. 5.1

The strings of the electric guitar are made of steel. When a string vibrates, an electrical signal is generated between the terminals of the coil.

(a)(i) State Faraday's law of electromagnetic induction. [1]

(ii) Use Faraday's law to explain why an electric signal is generated between the terminals of the coil. [3]

(iii) Suggest why nylon strings cannot be used for an electric guitar. [1]

(b) Consider a guitar string which is stretched between two fixed clamps 64.0 cm apart. The wire is set vibrating at its fundamental (lowest) frequency and the speed of the waves propagating along the string is 300 m s^{-1}.

Show that the string is vibrating at a frequency of 230 Hz. [2]

(c) Assume that the magnet (seen in Fig. 5.1) produces a uniform magnetic flux density of 4.50 mT over a 2.00 cm segment of the string. (The magnetic field over the rest of the string is negligible.) The section of the string in the magnetic field vibrates with an amplitude of 1.50 cm and in a direction that is perpendicular to the field. This means that, besides the e.m.f. induced in the pick-up coil, there is also an e.m.f. induced between the ends of the string.

Using your answer from (b), calculate the maximum e.m.f. induced between the ends of the string. (Ignore the e.m.f. induced in the pick-up coil.) [3]