PHYSICS PRACTICE TEST

TIME: 15 minutes for part A, 45 minutes in all

PART A: SHORT QUESTIONS

REMARKS:

- No aids (calculator, FoTa, formula sheet) allowed
- Always express numerical results as rounded decimal numbers (except in ratios)
- Derivation required for numerical results

1. On the reverse side of the sheet, describe a device used to select particles of a given velocity from a particle beam. Can the same arrangement work for different particles (e.g. electrons and protons)?

2. A styrofoam ball carrying a charge of + 5 nC is moving perpendicularly to the field lines of a homogeneous magnetic field which has a magnitude of 25 mT and points westward. It experiences a magnetic force of 7.5 nN. The direction of the force is straight down, toward the surface of the earth. What is the magnitude and direction of the ball's speed?

3. Which of the following statements are true?

   ☐ There is no magnetic equivalent of an electric point charge.

   ☐ The potential energy of a negatively charged particle in a magnetic field decreases along the field lines.

   ☐ In a loudspeaker, the frequency of the tone is determined by the ac current flowing through the coil

   ☐ The top end of a pole standing vertically on the surface of the earth in Canada is a magnetic south pole.

4. Determine the direction of the (Biot-Savart) force acting on the wire carrying the current I_1.
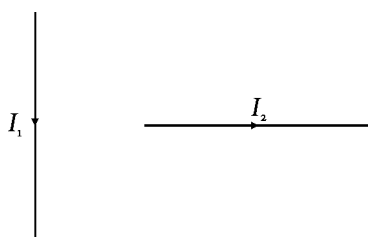
5. A 6 cm long, straight wire lying in the drawing plane carries a current of 1.5 A. It is placed in a homogeneous magnetic field with magnitude 11 mT. The orientations are given by the figure below. Determine the direction and the magnitude of the force acting on the wire.
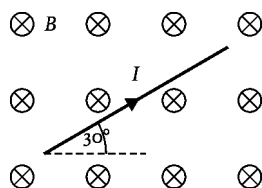

NUMERICAL SOLUTIONS: 2. 60 m/s; 3. ☑☐☑☐; 5. 0.99 mT

Part B: Problems

Remarks:
- Write your solutions to the problems on the answer sheet. Start a new page for every problem.
- An algebraic solution and all values used in calculations are required to get the full mark.
- Results must be rounded to at most three significant figures.

1. Natural uranium is mainly composed of the two isotopes uranium 235 and uranium 238.
   For an investigation of the composition, the uranium atoms are ionised by adding an additional electron.
   They are then accelerated in an electric field. The resulting ion beam is supposed to enter the mass spectrometer with a speed of exactly 25 km/s.

   a) The magnitude of the vertical electric field in the velocity selector is 220 V/m.
      What are the correct magnitude and direction of the magnetic field B_1 in the velocity selector in order for ions with the correct speed to traverse the velocity selector following a straight line trajectory?
      Draw the trajectory of an ion which moves faster than 25 km/s.
      Can the same velocity selector also be used to select protons with a speed of 25 km/s?

   b) In the mass spectrometer, the ions move in a homogeneous magnetic field oriented perpendicularly to the motion of the particles. After flying a semi-circle, they hit a photographic plate where their position is registered as a *spectral line*.
      The distance between the spectral lines for uranium 235 and uranium 238 shall measure 10 mm. Calculate the magnitude of the magnetic field B_2 in the mass spectrometer.
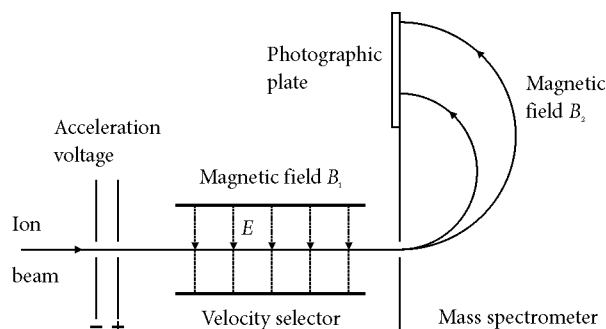
2. The rotor of an electric motor consists of a square-shaped coil (side length 12 cm) with 45 turns. Its resistance is 0.45 Ω. The coil is placed in a homogeneous magnetic field with magnitude 340 mT.

   a) Sketch the rotor and mark the directions of both the current in the coil and the magnetic field. Draw the force vector on one side of the rotor.

   b) How is it possible that the rotor continues rotating in the same direction?

   c) The motor is connected to a 12 V power supply. Calculate the force on one of the coil's sides.

   d) Assuming an efficiency of 95 %, calculate the mechanical power delivered by the motor.

Numerical Solutions: 1. 8.8 mT, 78 mT; 2. 49 Ω, 304 W