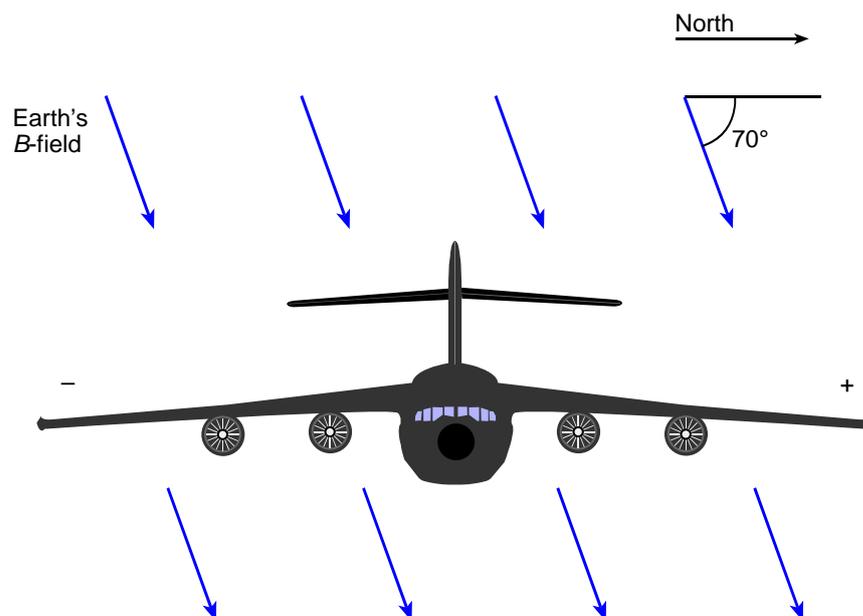


## TAP 414-8: Emf in an airliner

These questions are about the potential difference induced across the wings of an aeroplane flying through the Earth's magnetic field.

The charge on an electron =  $-1.6 \times 10^{-19}$  C

An airliner is flying due east from North America to Europe. The Earth's magnetic field acts at  $70^\circ$  to the horizontal, and has a strength of  $1.7 \times 10^{-4}$  T.



As the aircraft flies through the field, the north-pointing tip of the wing becomes positively charged and the south-pointing tip becomes negatively charged.

1. Explain why the wing tips become charged. Assume that the wings act as continuous electrical conductors.
2. On the diagram above, show the direction of the component of the Earth's magnetic field that is responsible for this horizontal movement of charge along the wings.
3. Calculate the magnitude of this component.
4. The aircraft's speed is  $270 \text{ m s}^{-1}$ . Calculate the horizontal component of the force exerted by the Earth's magnetic field on an electron in the wing.

5. The wing span of the aircraft is 60 m. Calculate the potential difference induced between the tips of the wings.

The shape of the Earth's magnetic field is as if there were a bar magnet at the centre of the Earth, aligned approximately along its rotational axis.

6. Explain why there is no significant voltage induced between the wing tips when the aircraft flies from west to east over the equator.

## Practical advice

These questions practise thinking about the emf in a conductor cutting magnetic flux.

## Answers and worked solutions

1. The wings cut the flux lines of the Earth's magnetic field, inducing an emf between the wing tips. An alternative answer is that the charges in the wings are moving through the Earth's magnetic field and experience a force which redistributes the charge in the wings.
2. Vertically downward arrow to show the vertical component.
3. Vertical component =  $(1.7 \times 10^{-4} \text{ T}) \cos 20^\circ = 1.6 \times 10^{-4} \text{ T}$ .
4.
$$F = qvB$$
$$= (1.6 \times 10^{-19} \text{ C}) \times 270 \text{ m s}^{-1} \times (1.6 \times 10^{-4} \text{ T})$$
$$= 6.9 \times 10^{-21} \text{ N}.$$
5.
$$\text{emf} = vLB$$
$$= 270 \text{ m s}^{-1} \times 60 \text{ m} \times (1.6 \times 10^{-4} \text{ T})$$
$$= 2.6 \text{ V}.$$
6. At the equator the aircraft is flying parallel to the flux and cuts no (or very little) flux.

## External reference

This activity is taken from Advancing Physics chapter 15, 260S