AP® Physics C: Electricity and Magnetism
2003 Sample Student Responses

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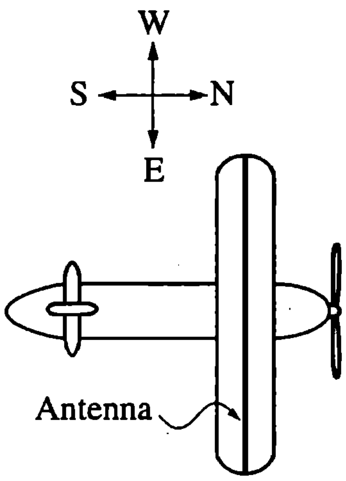
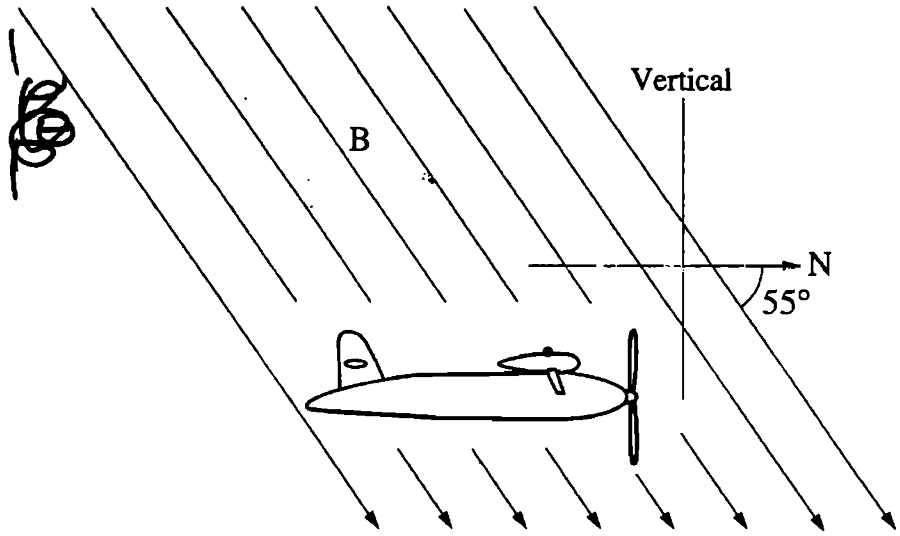


Top View

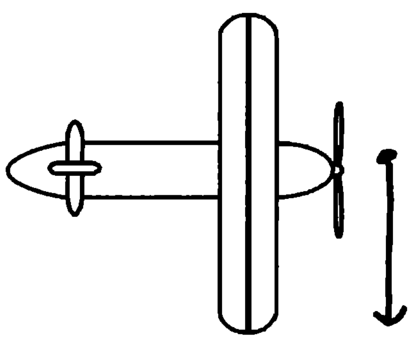


Side View

E&M. 3.

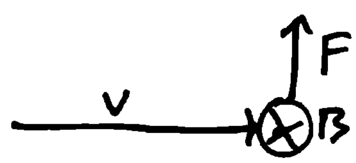
An airplane has an aluminum antenna attached to its wing that extends 15 m from wingtip to wingtip. The plane is traveling north at 75 m/s in a region where Earth's magnetic field has both a vertical component and a northward component, as shown above. The net magnetic field is at an angle of 55 degrees from horizontal and has a magnitude of 6.0×10^{-5} T.

(a) On the figure below, indicate the direction of the magnetic force on electrons in the antenna. Justify your answer.



$F = qv \times B$

Right hand rule –



But, since these are electrons, it goes in the opposite direction

(b) Determine the magnitude of the electric field generated in the antenna.

$\mathcal{E} = bv(l)$

$= b(v)\sin(55)\,l$

$= (6e{-5})(75)\sin(55)(15)$

$= .055$ = voltage difference across antenna

$\mathcal{E} = \frac{d(BA)}{dt}$

$= \frac{dA}{dt}(B)$

$= \frac{dx}{dt}(l)B$

$= B \times (v)(l)$

$E = \frac{\Delta V}{\Delta t} = \frac{.055}{15} = .00367\ \frac{N}{C}$

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(c) Determine the potential difference between the ends of the antenna.

<u>In</u> part (b):

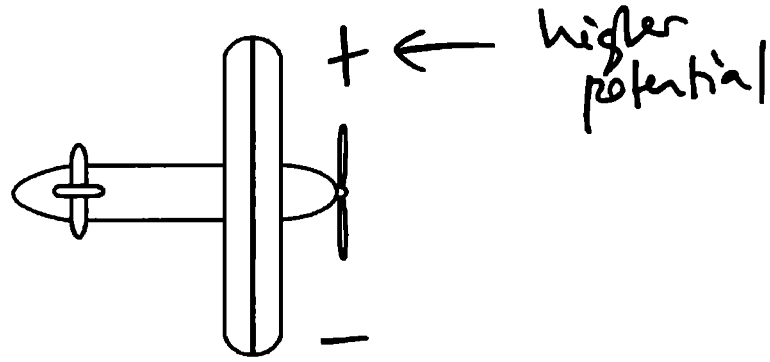
$V = \mathcal{E}MF = B \times V\,(l)$

$= 6E{-}5 \cdot \sin(55) \cdot 75 \cdot 15$

$= .055$ Volts

(d) On the figure below, indicate which end of the antenna is at higher potential.

right hand rule!



(e) The ends of the antenna are now connected by a conducting wire so that a closed circuit is formed.

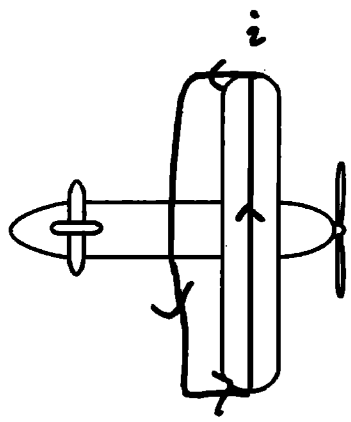
i. Describe the condition(s) that would be necessary for a current to be induced in the circuit. Give a specific example of how the condition(s) could be created.

For a current to be present, the B-Field or area (of the loop) must be changing. If the plane changes its vertical angle of flight for example, the B-field entering the loop will change, creating a current.

$\mathcal{E} = \frac{d\Phi_m}{dt} = d(BA)/dt$

ii. For the example you gave in i. above, indicate the direction of the current in the antenna on the figure below.

If the plane slowly curves till it is flying 35° with the vertical, the current would be as follows:



The ~~ϕ~~ current will try to resist the ↑ in b-field, moving counterclockwise.

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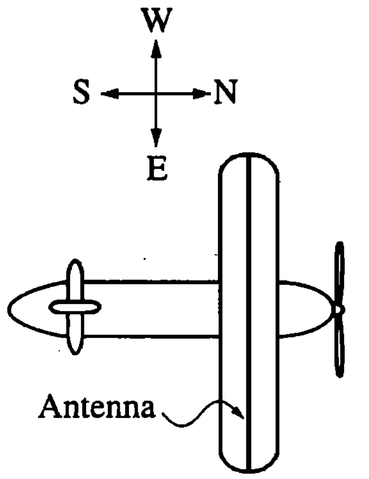
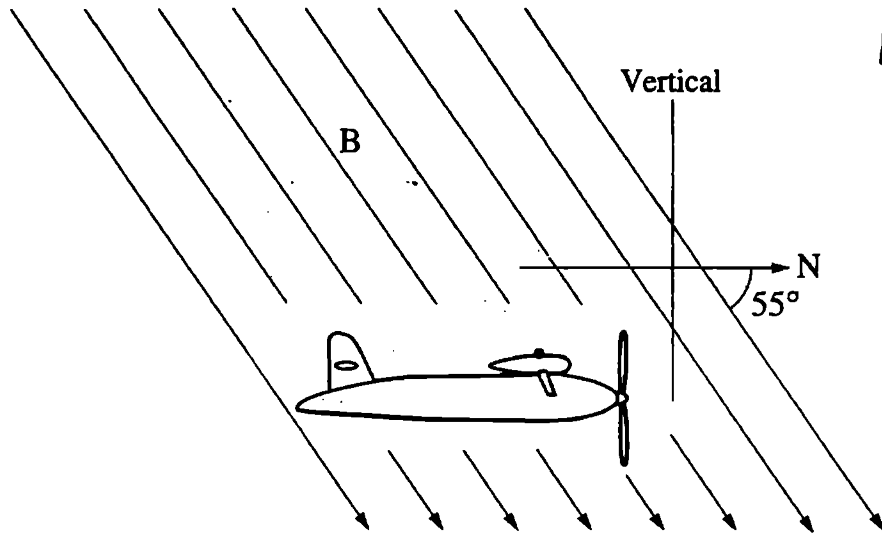
AB1



Top View

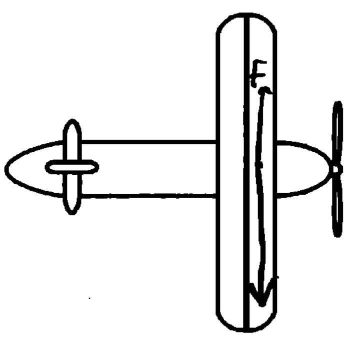


Side View

E&M. 3.

An airplane has an aluminum antenna attached to its wing that extends 15 m from wingtip to wingtip. The plane is traveling north at 75 m/s in a region where Earth's magnetic field has both a vertical component and a northward component, as shown above. The net magnetic field is at an angle of 55 degrees from horizontal and has a magnitude of 6.0×10^{-5} T.

(a) On the figure below, indicate the direction of the magnetic force on electrons in the antenna. Justify your answer.



$v \times B$ is toward the west end of the antenna, but since the charges are electrons, the force is in the opposite direction.

(b) Determine the magnitude of the electric field generated in the antenna.

$$E = \frac{F}{q} = \frac{\cancel{q} v \times B}{\cancel{q}} = v \times B = vB \sin\theta$$

$$E = 75 \cdot 6 \times 10^{-5} \sin 55$$

$$= 3.686 \times 10^{-3} \text{ N/C}$$

(c) Determine the potential difference between the ends of the antenna.

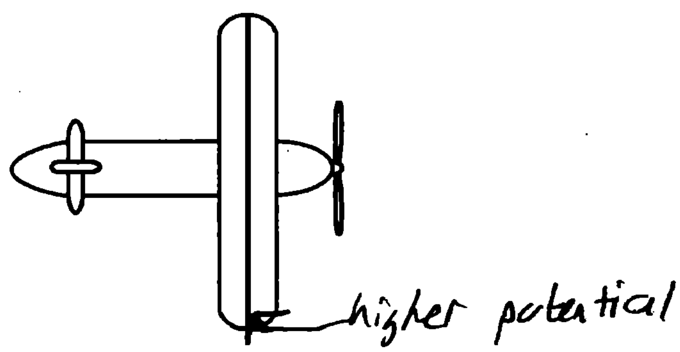
AB2

$V = Ed$

$V = 3.686 \times 10^{-3}\,N/C \cdot 15\,m$

$= 55.293 \times 10^{-3}\,V$

(d) On the figure below, indicate which end of the antenna is at higher potential.

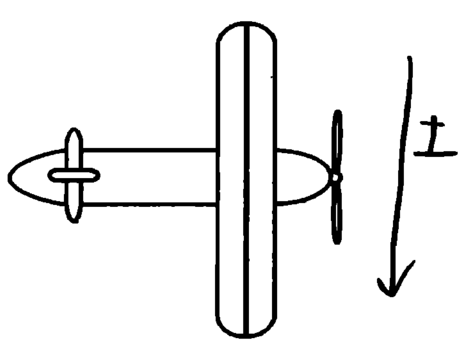


(e) The ends of the antenna are now connected by a conducting wire so that a closed circuit is formed.

i. Describe the condition(s) that would be necessary for a current to be induced in the circuit. Give a specific example of how the condition(s) could be created.

A change in magnetic flux would be necessary. It could be created by the plane changing the angle of its velocity from the horizontal so that it is a certain angle above the horizontal

ii. For the example you gave in i. above, indicate the direction of the current in the antenna on the figure below.



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