Notations

Force on a +ve charge

$\vec{F}$

velocity of a +ve charge

$\vec{v}$

magnetic field pointing from N to S

$\vec{B}$

← a +ve charge

↑ means pointing out of the paper

X ↑ means pointing into the paper.
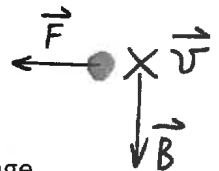
A

B

Conductive Rod

X

Y

+V-

I

Voltmeter
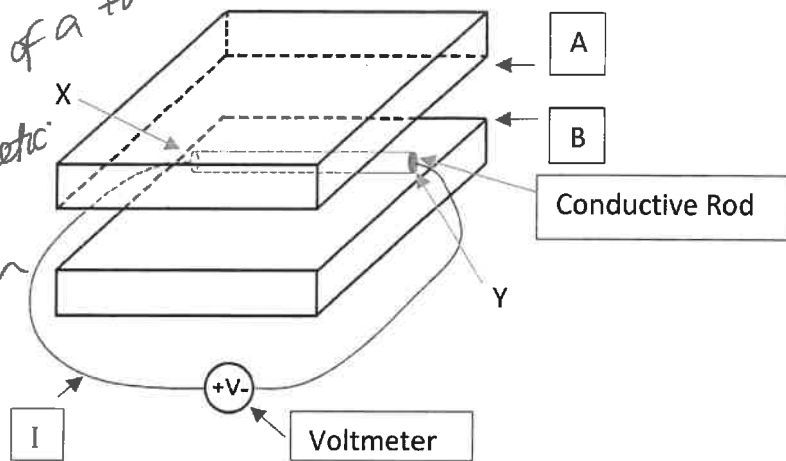
This diagram is for answering Q1 to Q5.

Q1   Given that A is a North pole and B, a South pole, what is the direction of the current, if any, when the rod is moved at a velocity backwards?

For Q1 & Q2

The current flows from left to right/ right to left / no current at the point marked by I.

Because the circuit is opened.

$\vec{F}$ ← ● X $\vec{v}$ ↓ $\vec{B}$

Q2   Given that A is a North pole and B, a South pole, what is the direction of the voltage when the rod is moved at a velocity backwards?

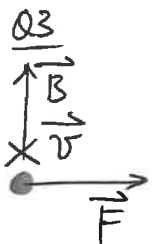The end marked X is negative/positive with respect to the end marked Y.

Q3   Given that A is a South pole and B, a North pole, what is the direction of the voltage when the rod is moved at a velocity backwards?

The end marked X is negative/positive with respect to the end marked Y.
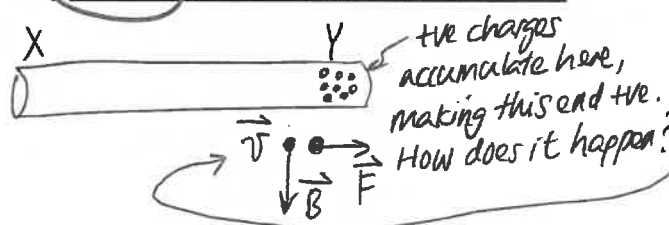
Q3

↑ $\vec{B}$
↓ $\vec{v}$
X
● ——→ $\vec{F}$

Q4   Given that A is a North pole and B, a South pole, what is the direction of the Lorentz force generated that acts on the rod, if any, when the rod is moved at a velocity backwards? In Q1 & Q2, once the charges are accumulated at X end, they will stop moving if the velocity of the rod is constant. Since there is no charge moving along the rod, there is no

The rod experiences a force forward/backward/upward/downward/no force   force that tries to oppose its motion back or forth.
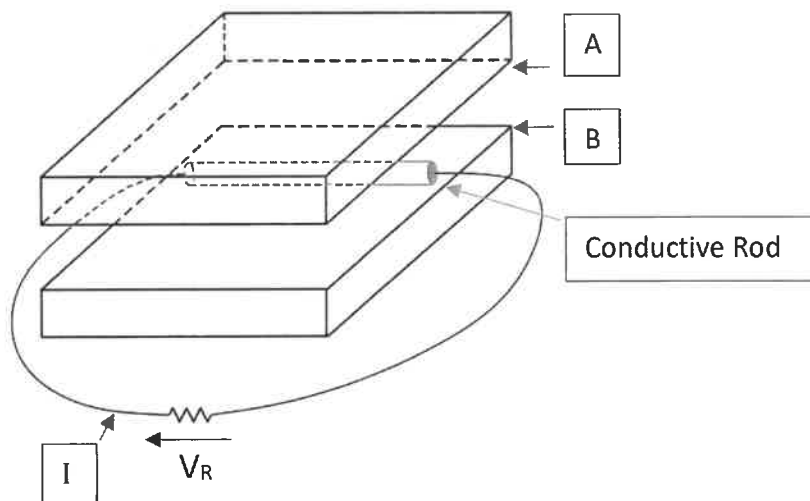
Q5   Given that A is a North pole and B, a South pole, and the voltmeter registers 3 V. In which direction is the rod moving?

The rod is moving forward/backward/upward/downward.

-ve indicates Y end is positive. That is, the Lorentz force is acting from left to right.

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X   Y — +ve charges accumulate here, making this end +ve. How does it happen?

$\vec{v}$ ● ——→ ↓ $\vec{B}$ $\vec{F}$

Ans It can only happen if the rod is moved forward, bringing the charge with it.

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Conductive Rod

A
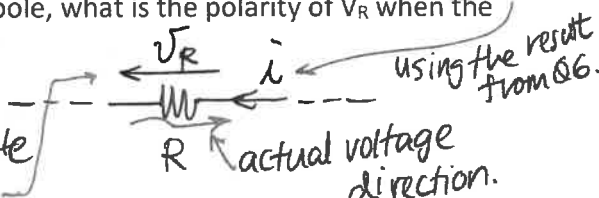
B

I V_R

This diagram is for answering Q6 to Q10

Q6   Given that A is a North pole and B, a South pole, what is the direction of the current, if any, when the rod is moved at a velocity forward?

The current flows from left to right/ right to left / no current at the point marked .
by I. Same situation as Q5 and we have seen that the +ve charges move to the right towards Yend. In Q6, the circuit is now closed and the charges can continue to flow and form a current.

Q7   Given that A is a North pole and B, a South pole, what is the polarity of V_R when the rod is moved at a velocity forward?

V_R is is negative/positive.

Because the actual voltage is opposite to the direction we measure it.

V_R i   using the result from Q6.
R   actual voltage direction.

Q8   Given that A is a South pole and B a North pole, what is the polarity of V_R when the rod is moved at a velocity forward?   Use the same reasonings employed for Q6 & Q7. The only difference is the reversal of the
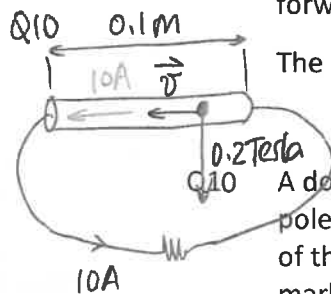
V_R is is negative/positive.   magnetic field. +ve charges move to the X end. $\vec{B}$ $\vec{F}$ $\vec{V}$
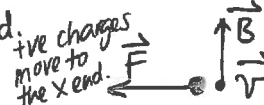
Q9   Given that A is a North pole and B, a South pole, what is the direction of the Lorentz force generated that acts on the rod, if any, when the rod is moved at a velocity forward?

The rod experiences a force forward/backward/upward/downward/no force

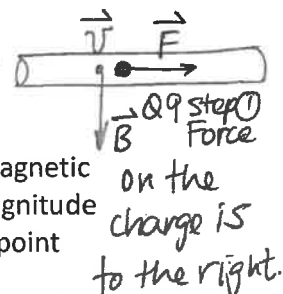$\vec{V}$ $\vec{F}$
$\vec{B}$ Q9 step①
Force on the charge is to the right.

Q10   0.1 m
10A $\vec{V}$
0.2 Tesla
10A
$F = BIL$
$= 0.2 \times 10 \times 0.1 = 0.2N$
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Q10   A downward pointing uniform magnetic field of 0.2 Tesla is created by the magnetic poles A and B and the rod is 0.1 m long. Determine the direction and the magnitude of the force on the rod when the current is 10 A flowing from left to right at point marked by I.
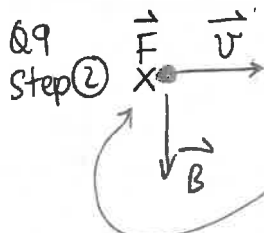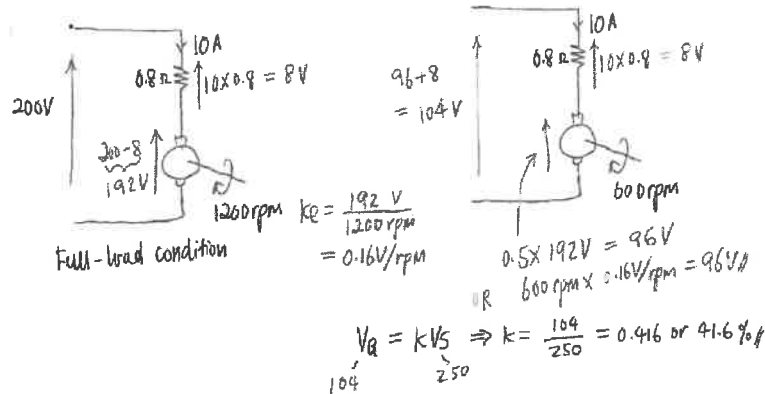
Q9 Step② $\vec{F}$ $\vec{V}$ As the charge moves to the
X right, another force is generated
$\vec{B}$ which is the the   Page 2 of 3
direction into the paper (backwards).
That is, the rod will experience a backward force.

Q11 A 200 V, 10 A, 1200 rpm separately-excited dc motor has an armature resistance of 0.8 Ω. It is driven by a chopper taking its supply from a 250 V dc source. Determine the duty cycle of the chopper when the motor is exerting the full-load torque at ½ the rated speed. The armature current is assumed to be continuous.

Ans: 41.6 %

Full-load condition

$k_e = \dfrac{192 \text{ V}}{1200 \text{ rpm}} = 0.16\text{V/rpm}$

$0.5 \times 192V = 96V$
$600 \text{ rpm} \times 0.16V/\text{rpm} = 96V$

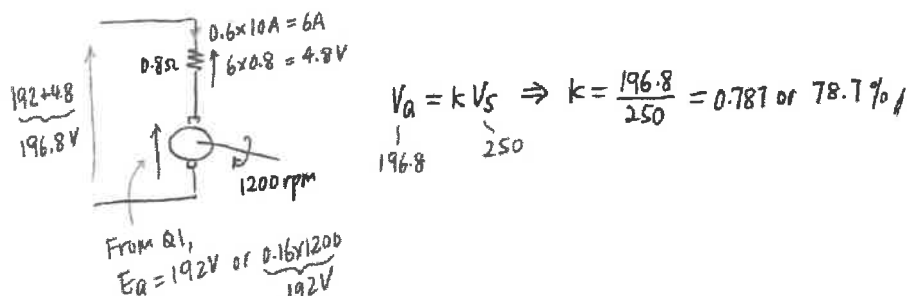$V_a = kV_s \Rightarrow k = \dfrac{104}{250} = 0.416 \text{ or } 41.6\%$

Q12 A 200 V, 10 A, 1200 rpm separately-excited dc motor has an armature resistance of 0.8 Ω. It is driven by a chopper taking its supply from a 250 V dc source. Determine the duty cycle of the chopper when the motor is exerting 60 % of full-load torque at the rated speed. The armature current is assumed to be continuous.

Ans: 78.7 %

$V_a = kV_s \Rightarrow k = \dfrac{196.8}{250} = 0.787 \text{ or } 78.7\%$

From Q1,
$E_a = 192V \text{ or } \underbrace{0.16 \times 1200}_{192V}$

Q13 A 200 V, 10 A, 1200 rpm separately-excited dc motor has an armature resistance of 0.8 Ω. It is driven by a chopper taking its supply from a 250 V dc source. Determine the duty cycle of the chopper when the motor is exerting 60 % of full-load torque at ½ the rated speed. The armature current is assumed to be continuous.

Ans: 40.3 %

$V_a = kV_s \Rightarrow k = \dfrac{100.8}{250} = 0.403 \text{ or } 40.3\%$