

**Next
Step**
TEST PREP

Physics

Today's Info Session

- ▶ Welcome to this Info Session!
- ▶ Introduction
- ▶ Physics
 - ▶ Electrostatics
 - ▶ Magnetism
 - ▶ Practice passage
- ▶ How Can Next Step Help?
- ▶ Questions?

Next
Step
TEST PREP

MCAT
Medical College
Admission Test

WHAT IS YOUR NEXT STEP?

Introduction

Hi, I'm Phil!

- ▶ **MCAT Content writer**
 - ▶ **Tutored and taught for 9+ years**
 - ▶ **Attended University of Nebraska Medical Center as an MD/PhD student.**
- ✓ **Next Step is a team of test prep and educational experts committed to excellence.**



Who Is Next Step?

Next
Step
TEST PREP

- Began in 2009 as a tutoring company
- Focus on graduate admissions tests only
- Team of educational experts
- First company to have materials built from ground up for 2015 MCAT format
- Now the first company to have new 2018 MCAT Interface

✓ **We never stop improving our materials!**



Electrostatics

One of the four fundamental forces of physics:

- ▶ Electromagnetism
- ▶ Gravity
- ▶ Strong Nuclear
- ▶ Weak Nuclear

The last two aren't on the MCAT. YAY!



Electrostatics

Difference between electrostatics and magnetism

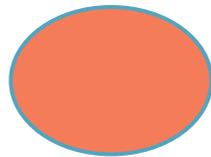
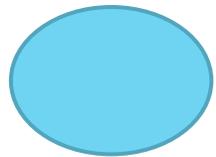
▶ **Electrostatics:**
Study of stationary charges

▶ **Magnetism:**
Moving charges

Electrostatics

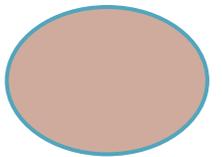
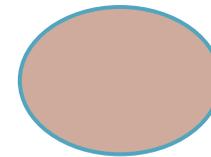
**Electrostatic
Force:**

$$F = kqQ / r^2$$



Gravity!

$$F = GmM / r^2$$



Electrostatics

Newton's!

Force:

$$F = kqQ / r^2$$

Joules!

Energy:

$$U = kqQ / r$$

$$\text{Joules} = \text{Nm}$$

$$\text{Energy} = \text{Force} \times \text{distance}$$

$$\text{Energy} = (kqQ / r^2) (r)$$

Electrostatics

Newton's!

Force:

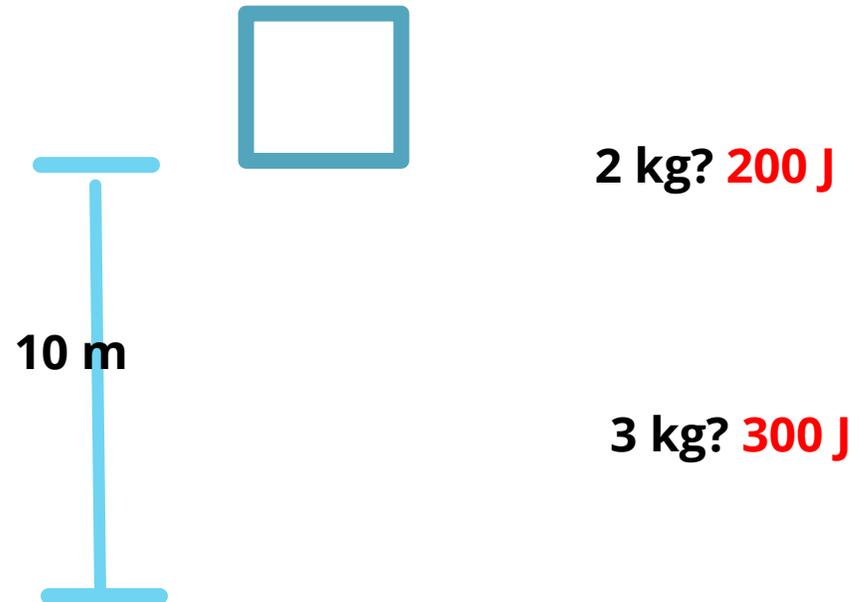
$$F = kqQ / r^2$$

This spot is 10 m above the ground, How much energy will a 1 kg object have *if* I put it in the spot? **100 J**

Joules!

Energy:

$$U = kqQ / r$$



Electrostatics

Newton's

Force:

$$F = kqQ / r^2$$

Joules

Energy:

$$U = kqQ / r$$

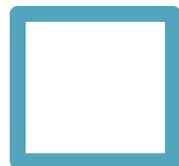
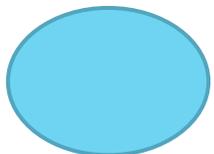
Potential

J/C

$$V = kq / r$$

A single charge will create a voltage. If we put in another charge, it will have energy.

Voltage = Joules/Coulomb



Electrostatics

Newtons

Force:

$$F = kqQ / r^2$$

N/C!

Electric field

$$E = kq / r^2$$

Electric fields are similar to voltage, but are N/C

Joules

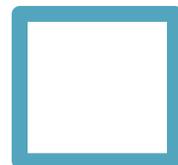
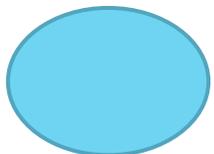
Energy:

$$U = kqQ / r$$

J/C

Potential

$$V = kq / r$$



Electrostatics

Force:

$$F = kqQ / r^2$$

Electric field

$$E = kq / r^2$$

Energy:

$$U = kqQ / r$$

Voltage

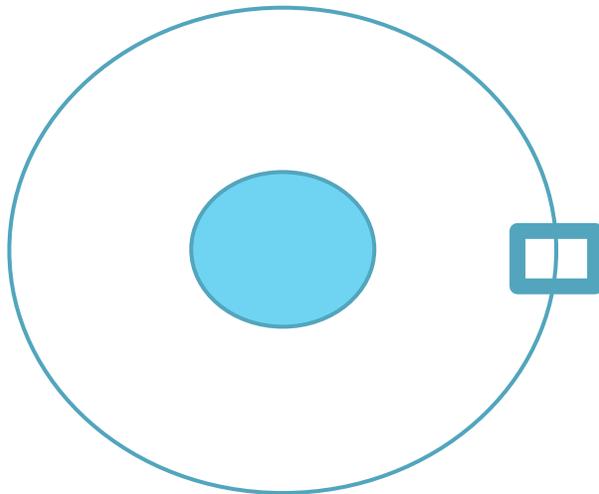
$$V = kq / r$$

$$U = Fr$$

$$V = Er$$

$$U = qV$$

$$F = qE$$



2m from a positive charge, there is a voltage of 30 Volts.
How much energy will a 2C charge have if I place it there?

$$U = qv \rightarrow 30V \times 2 C = 60 J$$

How much energy if I put a 3C charge at 4m?

At 4m, we have doubled the radius, so the Voltage is cut in half to 15 V.

$$U = qV \rightarrow 3C \times 15 V = 45 J$$

How much force will there be if I place a 6 C charge at 6m?

At 6m, the voltage drops to 10V.

Combining the 2 equations: $U = Fr$ & $U = qv \rightarrow Fr = qV$

$$F = qV/r \rightarrow F = (6C)(10V)/(6m) = 10N$$

Electrostatics

Force:

$$F = kqQ / r^2$$

Electric field

$$E = kq / r^2$$

Energy:

$$U = kqQ / r$$

Voltage

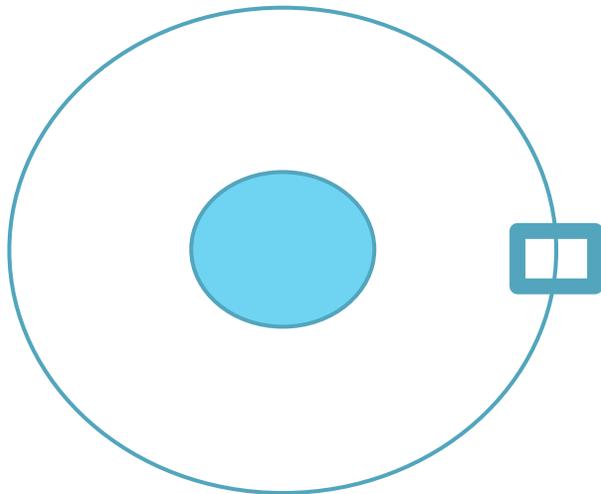
$$V = kq / r$$

$$U = Fr$$

$$F = Er$$

$$U = qV$$

$$F = qE$$



2m from a positive charge, there is a voltage of 30 Volts.

If I place a 2kg & -2C charge at 6m, how fast will it be going once it reaches 2m?

Using the methods we used before, we see that the charge will have -20J at 6m, and then -60J at 2m.

This means it loses 40J of electrostatic potential energy, but gains 40J of KE.

$40 = \frac{1}{2} mv^2 \rightarrow m$ is 2, so the equation becomes:

$$40 = v^2 .$$

This means it will be going between 6 and 7 m/s.

Magnetism

Magnetic fields are created by moving charges and exert forces on other moving charges.

$$B = \mu I / 2\pi r$$

$$\mu = 1.256 \times 10^{-6} \text{ N/A}^2$$



Magnetism

Right-hand-rule #1

Thumb = direction of current

Fingers = curl with magnetic field
(which is circular)

Into the page.

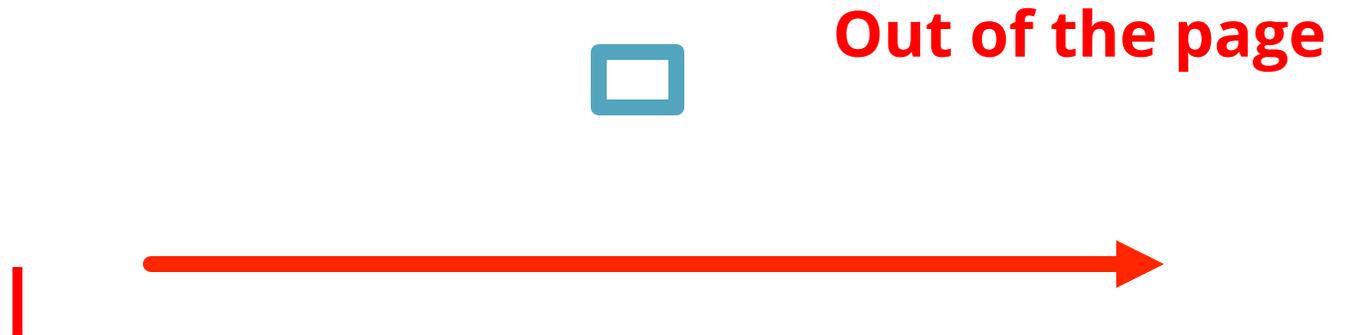


Magnetism

Right-hand-rule #1

Thumb = direction of current

**Fingers = curl with magnetic field
(which is circular)**



Magnetism

Magnetic fields exert forces on other moving charges. These moving charges could be :

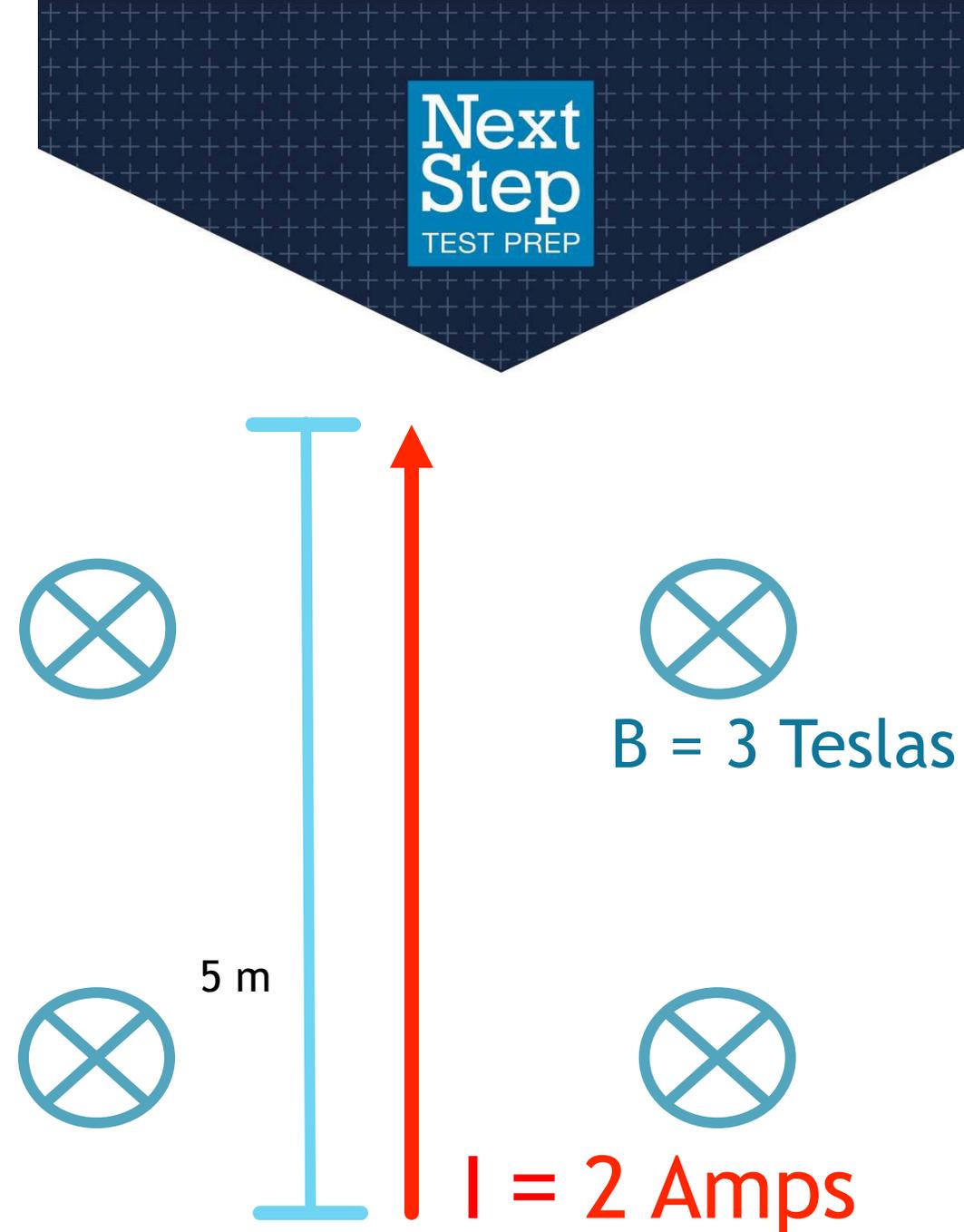
Particles (like a proton)

$$F = qvB \sin \theta$$

Current carrying wires

$$F = ILB \sin \theta$$

For this example, $F = 30\text{N}$



Magnetism

What about direction?

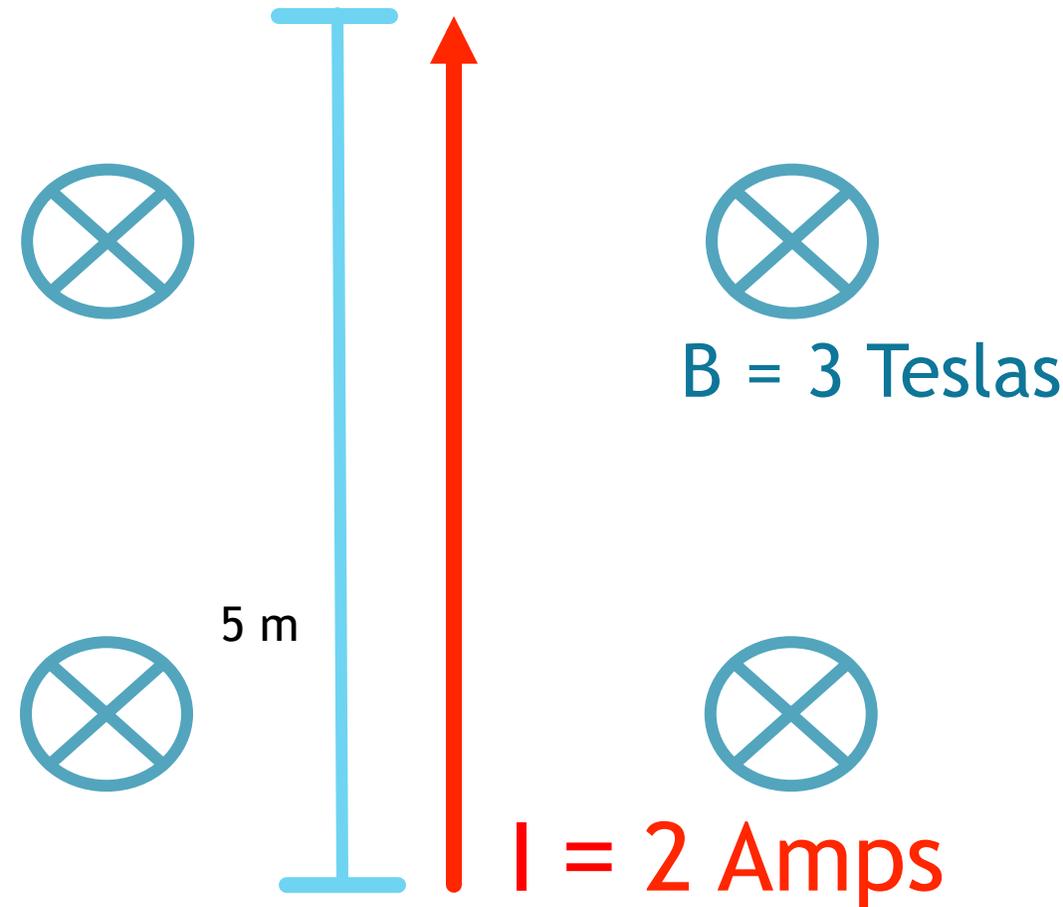
Right-hand-rule #2

Thumb = direction of velocity/ Current

Fingers = direction of B

Palm = direction of force

Force will be to the left.



Magnetism



They will curve around to the left and hit the wall.

Heavier molecules are harder to turn, so will hit further away from the hole.

This machine is a mass spec!



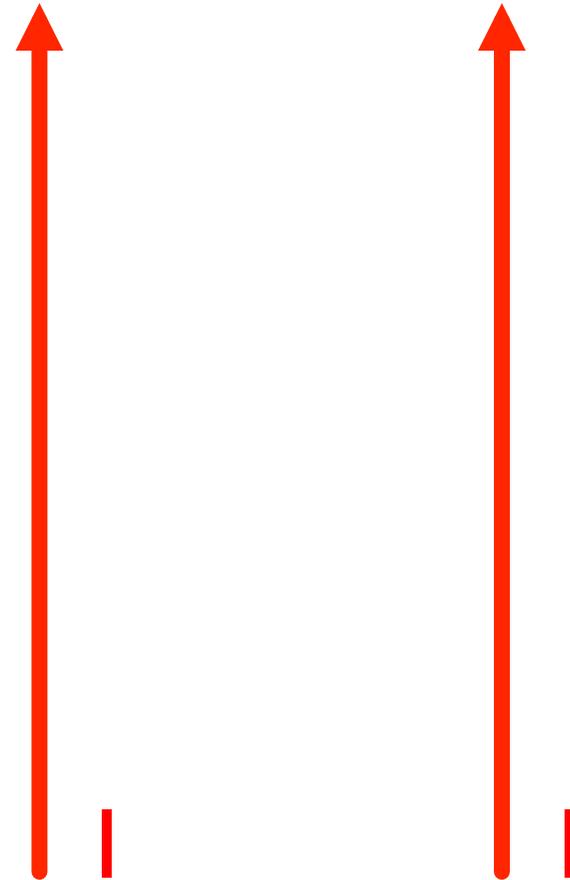
Q

I have a machine that gives molecules a positive charge and then shoots them into a room with a magnetic field at a set speed. What happens as I fire them into the room?

Magnetism

When wiring up a power plant, I run two wires in parallel, as shown. Will they exert forces on each other?

They will pull towards each other.



Practice Passage

Action potentials in neurons are often compared to a current-carrying metal wire. Both have electrical current moving in a single directional manner, though the current is caused by electron flow in a wire and positive ion flow in a neuron. When a neuron fires, the current travels down the axon, eventually reaching the axon button and triggering the connection at the synapse.

While magnetic resonance imaging (MRI) is usually used only to look at makeup of tissue, it has been speculated that an MRI machine could be adapted to detect nervous system activity. In the machine, the neuron is subjected to a large magnetic field. As the action potential move across the neuron, the neuron and surrounding tissue will be pulled, due to the presence of the Lorentz force. The direction of the magnetic field (B) generated by the MRI and of the current (I) along the nerve axon are shown in Figure 1. Since the neuron is relatively linear and the magnetic field is strong and constant, the resulting movement could be measured.

Practice Passage

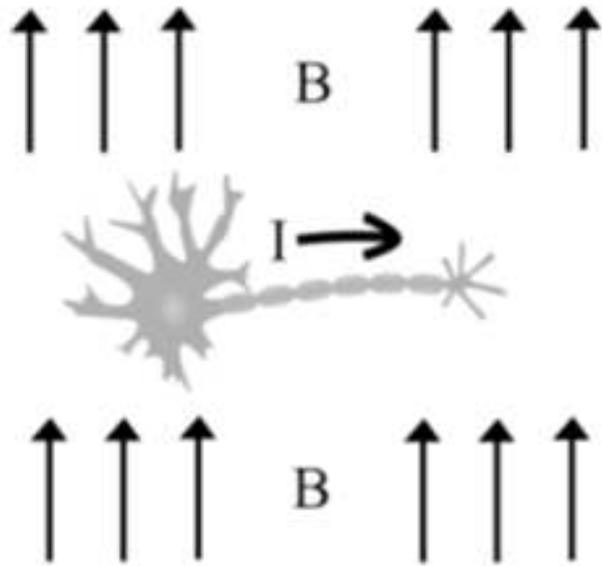


Figure 1 Neuron in a magnetic field (B) generated by an MRI machine

The magnitude of the force on a neuron depends on many factors, including the applied magnetic field and the thickness of the surrounding tissue. Another major factor is the radius of the neuron carrying the action potential, as larger neurons have more moving ions. The magnitude of the Lorentz force, and thus the total displacement of surrounding tissue, is directly proportional to the square of the radius of the neuron.

Practice Passage

Which of the following devices could be used to directly measure the strength of the action potential in a neuron.

- A. An Ammeter
- B. A barometer
- C. An ohmmeter
- D. A voltmeter

A is correct. An ammeter could be used to measure the strength of an action potential. Paragraph 1 notes that neurons are very similar to a current carrying wire, and an ammeter measures current, thus could directly measure the action potential.

B: A barometer measures pressure.

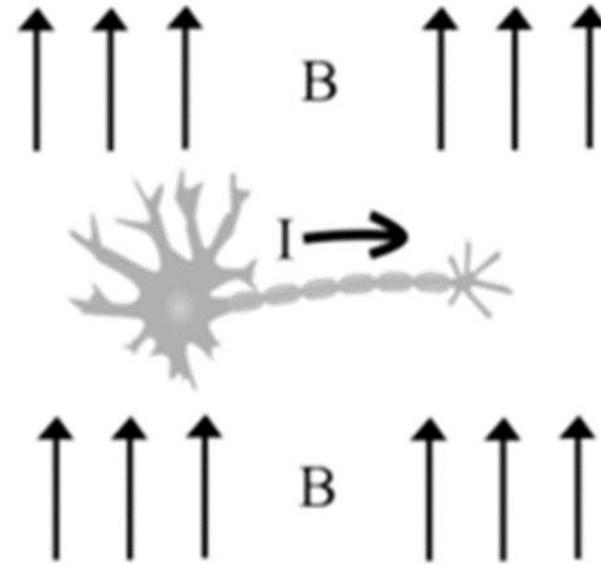
C: An ohmmeter measures resistance.

D: A voltmeter measure potential. While this may indirectly measure the current, more information is necessary to derive this.

Practice Passage

According to the diagram in Figure 1, what is the direction of the force on the neuron as shown?

- A. Upwards
- B. Out of the page
- C. To the right
- D. Into the page



B is correct. The force on the neuron will be out of the page. The right hand rule states that with the thumb pointed in the direction of the current and the other fingers in the direction of the magnetic field, the palm will point in the direction of the force on the wire. According to Figure 1, the thumb point right, the other fingers upwards, and the palm points outwards. Only the direction of the current and the magnetic field are necessary to use the right hand rule for the Lorentz force.

Practice Passage

According to the passage, why do researchers believe an MRI machine may be able to detect neuronal activity?

- A. Neurons are very thin and thus will show up well on an MRI.
- B. Active neurons are denser than dormant ones.
- C. Active neurons contain electrical current, thus generating their own magnetic fields.
- D. Active neurons contain electrical current and thus are moved by a magnetic field

D is correct. An active neuron contains electric current, is moved by a magnetic field, and thus could be detected by MRI. Paragraph 2 states that the action potential in the neuron generates a force because of the applied magnetic field.

A, B: The thickness of neurons is unrelated to the ability of a magnetic field to exert a force upon moving charges.

C: While a technically true fact, this is not involved in the method being described to detect neuronal activity.

Practice Passage

Compared to an unsheathed neuron, a neuron surrounded with a myelin sheath will:

- I. be unable to fire.
- II. propagate signals more quickly.
- III. have fewer supporting Schwann cells.

- A. I only
- B. II only
- C. I and II
- D. II and III

B is correct. A sheathed neuron will propagate signals more quickly than its unsheathed counterpart.

A, C, D: Both unsheathed and sheathed neurons can fire normally. The myelin sheath of the peripheral nervous system is produced by Schwann cells, so they are only around sheathed neurons.

Practice Passage

The researchers involved in prototyping the device described in the passage have found that it can detect neuronal activity in the limbs, but fails to detect brain activity. Which of the following would best explain this observation?

- A. Neurons in the brain have thicker lipid membranes than other neurons.
- B. Neurons in the brain are twisted, while peripheral neurons tend to be straight.
- C. Peripheral neurons generate small currents.
- D. Magnetic fields do not interact with currents.

B is correct. Neurons that are straight are required for measurement of the Lorentz force. As stated in paragraph two, a straight neuron produces a current capable of interacting with the magnetic field generated by the MRI machine. A twisted neuron could not do this since the direction of the resulting force would be constantly changing as the direction of the current changes and the detector would be unable to reliably measure this.

A: The thickness of neurons is unrelated to the ability of a magnetic field to exert Lorentz forces upon the neurons being investigated.

C: Current is necessary for the Lorentz force, and for test day we should know that all working nerves must be carrying a current (as the transmit action potentials).

D: Magnetic fields interact with currents to produce the Lorentz force, as stated in paragraph two.

Practice Passage

A positive ion is at rest in a non-polarized aqueous environment. Which of the following best describes the electric field lines in this situation?

- A. The field lines point perpendicular to the flow of water.
- B. The field lines encircle the ion.
- C. The field lines point away from the positive ion.
- D. The field lines point away from the positive ion.

C is correct. Electric field lines point away from a positive ion. Electric field lines show the direction a test charge (which is positive) will move within the given electric field. Since positive ions will repel each other, the field lines point directly away from a lone positive ion.

Practice Passage

During an experiment, researchers used an MRI machine to measure a $2\ \mu\text{m}$ displacement in an active ulnar nerve (with a radius of 1 mm and a length of 6 cm). According to the information presented in the passage, what would the displacement due to the Lorentz force on an active median nerve (with a radius of 2 mm and a length of 18 cm) be?

- A. $2\ \mu\text{m}$
- B. $4\ \mu\text{m}$
- C. $6\ \mu\text{m}$
- D. $8\ \mu\text{m}$

D is correct. The displacement due to the Lorentz force will be $8\mu\text{m}$. Paragraph three states that the magnitude of the Lorentz force, and thus the displacement, is proportional to the square of the radius of a neuron. The question states that a 1 mm neuron generates a $2\mu\text{m}$ displacement. A 2 mm neuron has twice the radius, thus the magnitude of the force will be $2^2 = 4$ times as great. $4(2\mu\text{m}) = 8\mu\text{m}$

Electricity and Magnetism

$$F = kQ_1Q_2 / r^2$$

$$F = qVB\sin \theta$$

$$F = iLB\sin \theta$$

$$V = IR$$

$$P = IV$$

$$R = \rho L / A$$

$$V_{rms} = V_{max} / \sqrt{2}$$

$$I_{rms} = I_{max} / \sqrt{2}$$

Resistors in series:

$$R_{tot} = R_1 + R_2 \dots$$

Resistors in parallel:

$$1/R_{tot} = 1/R_1 + 1/R_2 \dots$$

Capacitors in series:

$$1/C_{tot} = 1/C_1 + 1/C_2 \dots$$

Capacitors in parallel:

$$C_{tot} = C_1 + C_2 \dots$$

$$C = Q/V$$

$$\text{Energy} = (1/2)QV$$

$$F = qE$$

$$V = Ed$$

$$\text{Energy} = qEd$$

$$E = kQ/r^2$$

$$\text{Energy} = kQq/r$$

$$V = kQ/r$$

$$\Delta G = -nFE$$

$$E_{cell} = E_{cath} - E_{an}$$

Waves

$$v = f\lambda$$

$$T = 1/f$$

Light

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$\sin \theta_c = n_2/n_1$$

$$E = hf$$

$$m = -d_i / d_o$$

$$P = 1/f$$

$$f = (1/2)r$$

$$n = c/v$$

$$1/f = 1/d_i + 1/d_o$$

Sound

$$d\beta = 10 \log (I/I_0)$$

$$L = n\lambda/2 \quad (n=1, 2, \dots)$$

$$L = n\lambda/4 \quad (n=1, 3, \dots)$$

$$f_{beat} = |f_1 - f_2|$$

$$f = f_e [v \pm v_d] / [v \pm v_s]$$

Fluids

$$\rho = m/V$$

$$P = F/A$$

$$P = P_{atm} + \rho gd$$

$$F_b = \rho gV$$

$$Q = Av$$

$$P + \rho gy + (1/2) \rho v^2 =$$

constant

Gases

$$PV = nRT$$

$$\text{Boyle: } PV = k$$

$$\text{Guy-Lussac: } P/T = k$$

$$\text{Charles: } V/T = k$$

$$\text{Avogadro: } n/V = k$$

$$R_1/R_2 = \sqrt{m_2/m_1}$$

$$P_A = X_A \times P_{tot}$$

Solutions

$$pH = pK_a + \log (A^-/HA)$$

$$M = \text{mol} / L$$

$$m = \text{mol} / \text{kg}$$

$$N = M \times \# \text{ of } H^+$$

$$pH = -\log [H^+]$$

$$M_i V_i = M_f V_f$$

$$\Pi = MRT$$

$$\Delta T_f = i k_f m$$

$$\Delta T_b = i k_b m$$

$$X_A = \text{mol}_A / \text{mol}_{tot}$$

Thermo

$$\Delta U = Q - W$$

$$\Delta U = (3/2)nRT$$

$$W = P\Delta V$$

$$Q = mc\Delta T$$

$$Q = mH_L$$

$$\Delta G = \Delta H - T\Delta S$$

$$\Delta H_{rxn} = \Delta H_{prod} - \Delta H_{react}$$

Kinematics

$$v_f = v_o + at$$

$$d = v_o t + (1/2)at^2$$

$$v_f^2 = v_o^2 + 2ad$$

$$a_c = v^2 / r$$

$$F_c = mv^2 / r$$

$$v_x = v_o \cos \theta$$

$$v_y = v_o \sin \theta$$

Mechanics

$$F = ma$$

$$F_{a \text{ on } b} = -F_{b \text{ on } a}$$

$$F_{fric} = \mu F_N$$

$$F_g = GM_1 m_2 / r^2$$

$$F_g = mg$$

$$F = kx$$

$$\tau = rF \sin \theta$$

$$P = W/t$$

$$W = Fd \cos \theta$$

$$E_K = (1/2)mv^2$$

$$U = mgh$$

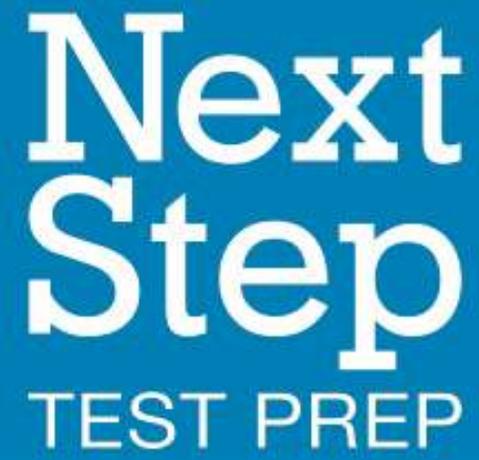
$$U = -GM_1 m_2 / r$$

Inclined Plane

$$F_{incline} = mg \sin \theta$$

$$F_N = mg \cos \theta$$

$$F_{fric} = \mu mg \cos \theta$$

The logo for Next Step Test Prep is centered in a blue square. The words "Next" and "Step" are stacked vertically in a large, white, sans-serif font. Below them, the words "TEST PREP" are written in a smaller, white, all-caps, sans-serif font. The background of the slide is dark blue with a repeating pattern of small white plus signs. A white inverted triangle shape is at the bottom of the slide.

Next
Step
TEST PREP

Q&A

Next Step: Core Values

Next
Step
TEST PREP



Educate Daily



Approachability



Authenticity



Professionalism



Ownership

We are dedicated to providing personalized support, advice and prep options that match each student's individual needs.

Students Have a Choice

- ✓ **Over 50,000 students have used Next Step Test Prep in their MCAT Prep journey**
- Always up-to-date content, strategy and tests
- Guaranteed Satisfaction
- Expert instructors on call for you
- No call center – instead, Academic Managers guide you all the way!

Next
Step
TEST PREP



4.7



Personalized Options

Next
Step
TEST PREP

✓ No matter your study style, subject expertise, or MCAT goal, Next Step has an option for your personal needs and lifestyle.

- **Self-Prep Materials and Planning**
- **Guided Online Study with Free Extra Help**
- **Flexibility and Personalization**
- **One-on-One Tutoring**



Next Step: Educate Every Da

- ✓ Start your prep with high-value FREE practice to build a study plan suited to your goals, needs, and schedule.

Industry's Best Free MCAT Practice Bundle

- Half-length MCAT diagnostic
- Full-length MCAT exam
- 500+ Question Science Content Diag exam
- Test Review Videos
- Multiple QBank Samples
- 16 Test & 4 Content Review Videos
- Proprietary Study Plan Generator
- Aligned to new MCAT 2018 Interface

Get your
**FREE MCAT Practice
Bundle**

[https://nextstestprep.com/
smith](https://nextstestprep.com/smith)

Additional Free Resources

Next
Step
TEST PREP

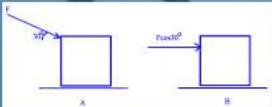
✓ Supplement your prep with additional support tools

- Question of the Day Quick Prep
- YouTube, Facebook and Instagram Content
- Ongoing Public Webinars and Q&A Sessions
- MCAT Blog: Content and Admissions
- Next Step MCAT Forum

NextStep
TEST PREP

Question of the Day

Two people push a box along a frictional surface. One pushes the box at an angle of 30° to horizontal with force F while the other pushes the box horizontally with force $F\cos 30^\circ$. Which person does the most work?

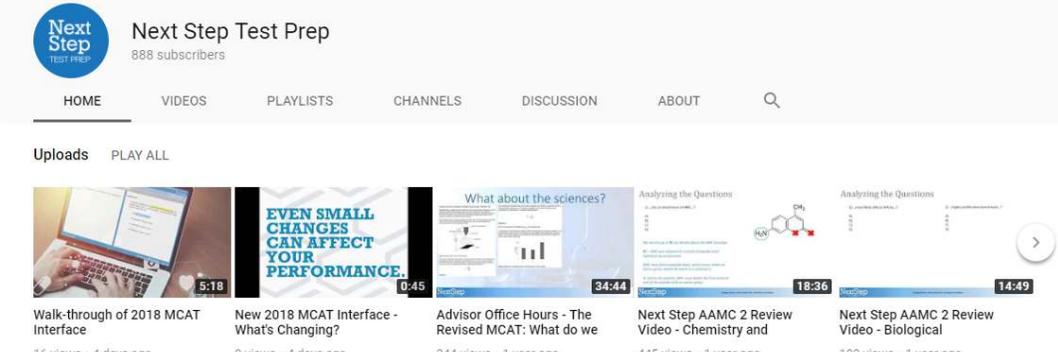


A) Person A
B) Person B
C) Person A and B do equal amounts of work
D) cannot be determined

Next Step Test Prep
888 subscribers

HOME VIDEOS PLAYLISTS CHANNELS DISCUSSION ABOUT Q

Uploads PLAY ALL



Walk-through of 2018 MCAT Interface
16 views • 4 days ago

New 2018 MCAT Interface - What's Changing?
9 views • 4 days ago

Advisor Office Hours - The Revised MCAT: What do we
344 views • 1 year ago

Next Step AAMC 2 Review Video - Chemistry and
445 views • 1 year ago

Next Step AAMC 2 Review Video - Biological
182 views • 1 year ago

New 2018 MCAT Interface

Next
Step
TEST PREP

- New highlighting features
- New strikethrough features
- New keyboard shortcuts
- New Navigation/Review Screens

Next Step is ready. Are you?

Medical College Admission Test - Clara Gillan Time Remaining: 01:21:34 18 of 59

Highlight Strikethrough

Remove Highlight

Pause

Figure 1 Eosinophil activation as measured by percent of CD69-positive cells after 3 and 12 hours of co-culture (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

Next, researchers aimed to assess the effect of NK co-culture on eosinophil degranulation. After 3 and 12 hours of co-culture, samples were centrifuged at 1500 rpm, and ECP levels were measured in the supernatants (Figure 2). No ECP was detected in supernatant culture of NK cells alone.

Question 18

Which of the statements below is supported by the experimental results, as shown in Figures 1 and 2?

- A. The duration of Eos co-culture with NK cells directly and linearly correlates to the amount of ECP found in the supernatant after centrifugation.
- B. Cells cultured with a 1:1 NK-to-Eos ratio displayed statistically similar levels of activation to cells cultured with a 5:1 NK-to-Eos ratio, as measured by CD69 expression.
- C. NK co-culture stimulates Eos activation while inhibiting degranulation.
- D. Co-culture with NK cells significantly increased Eos degranulation in all groups, as compared to Eos cells cultured alone.

Periodic Table Review Screen

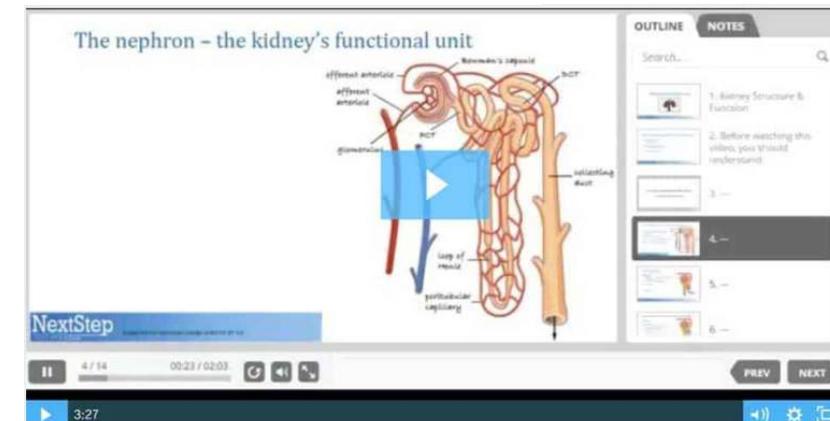
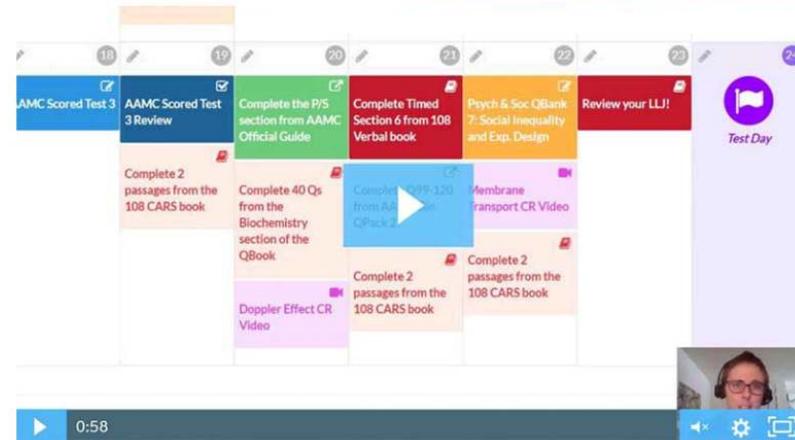
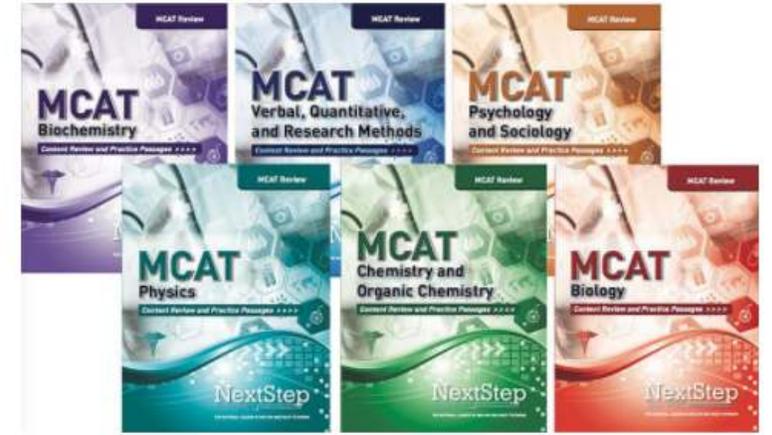
Previous Next

✓ Your practice experience matters! Prep with the most realistic testing environment with Next Step.

Take the Best Next Step

✓ Others say it. We deliver it.

- Most up-to-date Lesson Review Books in 4-color
- QBank with passage and discrete question types
- Exclusive Study Plan Generator personalized for you
- Hundreds of hours of videos
- Private, small-group Office Hours 5 days a week
- Direct access to MCAT Content Team
- Affordable prep options: from books to tutoring



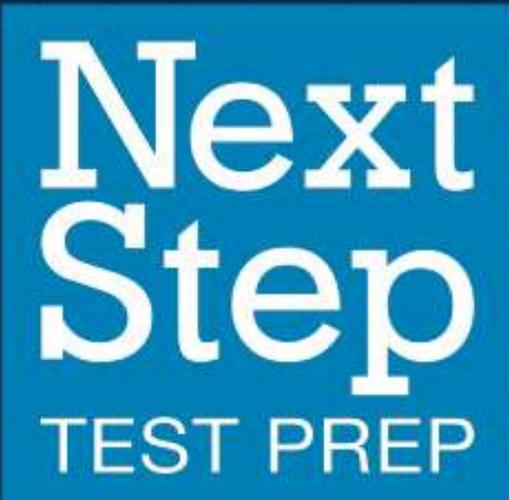
MCAT Study Options

- **Best-in-Class MCAT Tutoring Packages**
 - Variety of packages: Crash Course to Elite
 - Choices include our MCAT Online Course
 - Personalized Study Plan for each student
 - Top-scoring tutors
- **Most up-to-date MCAT Course**
 - All new books in 4-color, all online AAMC resources
 - 10 full-length exams aligned to new interface
 - Live online office hours for any Q&A held 5 days per week
 - Study Plan Generator to match each student's strengths, weaknesses and schedule needs.
- **MCAT Practice Test Bundles**
 - Available in 4-, 6-, and 10-pack bundles

✓ **All aligned to new 2018 interface**

Looking for free resources, or interested in signing up for future webinars?

nextsteptestprep.com/smith/

The logo for Next Step Test Prep is centered in a blue square. It features the words "Next Step" in a large, white, sans-serif font, with "Next" on the top line and "Step" on the bottom line. Below "Step", the words "TEST PREP" are written in a smaller, white, all-caps, sans-serif font.

Next
Step
TEST PREP

— — — — —

Step

CALL 888-530-6398 FOR A FREE CONSULT