How Things Work - Practice Exam 2B Solutions

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Question 1

A positive charge and a negative charge will:

- **(a)** attract each other.
- **(b)** repel each other.
- **(c)** attract or repel, depending on circumstances.
- **(d)** neither attract nor repel.

Solution:

According to **Coulomb's Law**, opposite charges attract each other, while like charges repel. Therefore, a positive charge and a negative charge will always attract each other.

The correct answer is **(a)**: attract each other.

Question 2

You are making electrostatics measurements. If you have a charge of +3C and your friend a charge of -5C, what is the overall net electric charge?

- **(a)** +2C
- **(b)** -2C
- **(c)** +8C
- **(d)** -8C

Solution:

To find the net charge, simply add the charges together:

$$\text{Net charge} = +3C + (-5C) = -2C$$

The correct answer is **(b)**: -2C.

Question 3

After removing your clothes from the dryer, a sock clings to your jeans with static electricity. As you pull them apart, the forces between them weaken because:

- **(a)** the electric charge on each garment increases as they move apart.
- **(b)** the electric current passing through each garment diminishes as they move apart.
- **(c)** the electric charge on each garment diminishes as they move apart.
- **(d)** the distance between the garments increases.

Solution:

The force between the garments weakens as the distance increases. According to **Coulomb's Law**:

$$F = k\frac{q_1 q_2}{r^2}$$

As the distance r increases, the force F decreases proportionally to r^2. The charges on the garments remain the same, but the increased distance reduces the force.

The correct answer is **(d)**: the distance between the garments increases.

Question 4

Which of the following can cause a charged particle to accelerate?

- **(a)** An electric field
- **(b)** A gravitational field
- **(c)** Neither (a) nor (b)
- **(d)** (a) and (b)

Solution:

An electric field exerts a force on a charged particle, causing it to accelerate according to:

$$\vec{F} = q\vec{E}$$

Additionally, gravitational fields also cause all objects, including charged particles, to accelerate due to gravitational force:

$$\vec{F}_{\text{grav}} = m\vec{g}$$

Therefore, both fields can cause acceleration.

The correct answer is **(d)**: (a) and (b).

Question 5

You need to install a lightning rod for your house. An informed hardware salesperson explains that lightning rods:

- **(a)** attract lightning.
- **(b)** repel lightning.
- **(c)** use corona discharge to bleed off local charge accumulations.
- **(d)** use electrostatic precipitation to remove excess charge from the air.

Solution:

Lightning rods work by using **corona discharge** to slowly neutralize the buildup of charge in the surrounding air, preventing large electric fields that can lead to lightning strikes.

The correct answer is **(c)**: use corona discharge to bleed off local charge accumulations.

Question 6

The surface of a photoconductor has been coated with electric charge. This charge will remain in place until you expose the surface to:

- **(a)** an electric field.
- **(b)** a magnetic field.
- **(c)** both an electric field and a magnetic field.
- **(d)** light.

Solution:

Photoconductors only conduct electricity when exposed to light. The energy from light frees electrons, allowing charge to flow. Without light, the charge remains stationary.

The correct answer is **(d)**: light.

Question 7

You are building metal objects for a science lab to hold charge for a long time. The object should not be:

- **(a)** insulated from everything else.
- **(b)** smooth.
- **(c)** sharp and pointed.
- **(d)** circular.

Solution:

Sharp points on conductors allow charge to escape due to **corona discharge**, reducing the ability to hold charge over time. Smooth, rounded surfaces minimize this effect.

The correct answer is **(c)**: sharp and pointed.

Question 8

In a short circuit,

- **(a)** current flows normally.
- **(b)** no current flows.
- **(c)** electrons can take a short cut.
- **(d)** only small currents can flow.

Solution:

In a short circuit, the current bypasses the normal path, taking a "shortcut" through a path of very low resistance, often causing excessive current to flow.

The correct answer is **(c)**: electrons can take a short cut.

Question 9

Your pet tiger has chewed the cord to your desk lamp and has created an open circuit—an electronic rift between two points. When you plug the lamp into the electric outlet:

- **(a)** current will bypass the bulb and the bulb will not light up.
- **(b)** current will flow alternately through the bulb and through the open circuit, so that the bulb will blink on and off rapidly.
- **(c)** no current will flow at all and the bulb will not light up.
- **(d)** excessive current will pass through the bulb and the bulb will glow very brightly.

Solution:

In an open circuit, the current cannot flow because the circuit is incomplete. Using **Ohm's Law**:

$$V = IR$$

If the circuit is open, the resistance R becomes effectively infinite, making the current $I = 0$:

$$I = \frac{V}{R} \to 0 \quad \text{as} \quad R \to \infty$$

Therefore, no current will flow, and the bulb will not light up.

The correct answer is **(c)**: no current will flow at all and the bulb will not light up.

Question 10

You are installing a new battery in your car. Although there are two terminals on the battery you hook up only one of your car's battery cables to the battery. Hooked up like this, the current that would then flow through the headlights when turned on is

- **(a)** zero.
- **(b)** twice the current that flowed when both terminals were present and plugged in.
- **(c)** the same as the current that flowed when both terminals were present and plugged in.
- **(d)** half the current that flowed when both terminals were present and plugged in.

Solution:

Without both terminals connected, the circuit is incomplete and no current can flow through the headlights.

The correct answer is **(a)**: zero.

Question 11

For an appliance to receive and consume electric power:

- **(a)** a current must flow through it across a voltage decrease.
- **(b)** it must polarize the current with its magnetic field.
- **(c)** a current must flow through it across a voltage increase.
- **(d)** it must magnetize the current with its electric field.

Solution:

The appliance consumes power if a current flows across a voltage drop. Using the **power equation**:

$$P = IV$$

For power to be consumed, current I must flow through the device, and the voltage V must decrease as energy is dissipated.

The correct answer is **(a)**: a current must flow through it across a voltage decrease.

Question 12

A light bulb is rated at 100W. This means that

- **(a)** the light bulb needs to be connected to 100V.
- **(b)** the light bulb consumes 100 J of energy per second.
- **(c)** the light bulb has 100Ω of resistance.
- **(d)** the light bulb operates with a 100A current.

Solution:

Power is the rate of energy consumption, and 1 watt equals 1 joule per second:

$$P = \frac{E}{t} = 100W \Rightarrow 100J/s$$

The correct answer is **(b)**: the light bulb consumes 100 J of energy per second.

Question 13

A car stereo draws 24A of current at voltage 12V. What power does it use?

- **(a)** 288W
- **(b)** 24W
- **(c)** 12W
- **(d)** 2W

Solution:

The power consumed by an electrical device can be calculated using the formula:

$$P = IV$$

Given that $I = 24A$ and $V = 12V$:

$$P = 24 \times 12 = 288W$$

The correct answer is **(a)**: 288W.

Question 14: BONUS!

Two 1.5V batteries placed end-to-end power a flashlight. If the current in the circuit is 0.6A, what is the resistance in the bulb?

- **(a)** 5.0 Ω
- **(b)** 2.5 Ω

- **(c)** 1.8 Ω
- **(d)** 0.9 Ω

Solution:

To calculate the resistance, use **Ohm's Law**:

$$V = IR \Rightarrow R = \frac{V}{I}$$

The total voltage is the sum of the two batteries:

$$V = 1.5V + 1.5V = 3V$$

With $I = 0.6A$:

$$R = \frac{3V}{0.6A} = 5.0\,\Omega$$

The correct answer is **(a)**: 5.0 Ω.

Question 15

Why is it nearly impossible to float one permanent magnet directly above another permanent magnet indefinitely by turning their north poles toward one another?

- **(a)** Two north poles attract one another and the two magnets will pull together until they touch.
- **(b)** That arrangement is unstable—the upper magnet will fall to the side or flip over.
- **(c)** The repulsive forces between magnets cannot overcome the gravitational forces between them, so the upper magnet cannot float.
- **(d)** Because they are stationary, the two magnets exert no forces on one another and the top magnet falls.

Solution:

When two like poles are placed together, they create an unstable equilibrium. The slightest disturbance causes the upper magnet to either fall to the side or flip over.

The correct answer is **(b)**: That arrangement is unstable—the upper magnet will fall to the side or flip over.

Question 16

Which is not a characteristic of hard magnetic materials?

- **(a)** They are hard to magnetize.
- **(b)** They easily lose their magnetization.
- **(c)** They are used in magnetic tapes.
- **(d)** They have microscopic structures and defects that impede the resizing of domains.

Solution:

Hard magnetic materials retain their magnetization well and are difficult to demagnetize. Using **angular momentum** for magnetic materials:

$$\Delta L = \tau \Delta t$$

Hard materials have high resistance to torque τ, meaning their magnetic domains do not realign easily, which is why they don't lose magnetization easily.

The correct answer is **(b)**: They easily lose their magnetization.

Question 17

When you drop the north pole of a permanent magnet onto an aluminum sheet, it falls slightly slower than normal. The magnet is being repelled by the aluminum because:

- **(a)** aluminum is positively charged and repels approaching magnetic poles.
- **(b)** aluminum has a net north magnetic pole that repels any approaching north poles.
- **(c)** aluminum has a net south magnetic pole that repels any approaching north poles.
- **(d)** current induced in the aluminum by the approaching north pole produces a repelling north pole on the aluminum's surface.

Solution:

As the north pole of the magnet approaches the aluminum, **Lenz's Law** explains that an induced current is generated in the aluminum. This current creates a magnetic field that opposes the motion of the approaching magnet, generating a repelling force. Using the **magnetic force equation**:

$$F_{\text{mag}} = \mu_0 \frac{p_1 p_2}{r^2}$$

The induced magnetic field repels the magnet.

The correct answer is **(d)**: current induced in the aluminum by the approaching north pole produces a repelling north pole on the aluminum's surface.

Question 18

A permanent magnet and a magnetizable material like steel:

- **(a)** always attract.
- **(b)** can attract or repel.
- **(c)** always repel.
- **(d)** never have stable force interactions.

Solution:

A permanent magnet always attracts a magnetizable material like steel, regardless of the poles, because the steel becomes temporarily magnetized with an opposite pole.

The correct answer is **(a)**: always attract.

Question 19: BONUS!

Although you would like for your date to have a magnetic personality, the field of magnetic dating is about something else altogether. The idea is that magnetic rocks get very hot in or near a fire and then when they cool down they take on the magnetic field of the earth at whatever time they cooled. The reason heat is needed is because:

- **(a)** there need to be enough thermal fluctuations to disorient the magnetic domains and cause the rock to be non-magnetic.
- **(b)** there need to be enough thermal fluctuations to disorient the magnetic domains and cause the rock to be magnetic.
- **(c)** the fire causes a chemical reaction on the surface of the rock that preserves magnetic field direction.
- **(d)** fire is just dramatic.

Solution:

Heat provides the energy necessary for the magnetic domains to become disoriented, allowing them to realign with the Earth's magnetic field as the rock cools down.

The correct answer is **(b)**: there need to be enough thermal fluctuations to disorient the magnetic domains and cause the rock to be magnetic.

Question 20

The power supply for your answering machine is a small black cube that plugs directly into an electric outlet. The main component in this supply is a transformer and moderate current from the 120 V power line flows through the primary coil of this transformer. If the transformer's primary coil has 20 times as many turns of wire in it as the secondary coil has, then the secondary coil provides:

- **(a)** a larger voltage and a larger current than the primary.
- **(b)** a smaller voltage and a larger current than the primary.
- **(c)** a smaller voltage and a smaller current than the primary.
- **(d)** a larger voltage and a smaller current than the primary.

Solution:

A transformer changes voltage and current based on the ratio of the number of turns in the primary and secondary coils. Since the primary has 20 times more turns than the secondary:

- **Voltage:**

$$V_s = V_p \times \frac{N_s}{N_p} = V_p \times \frac{1}{20}$$

  The secondary voltage is smaller.

- **Current:**

$$I_s = I_p \times \frac{N_p}{N_s} = I_p \times 20$$

The secondary current is larger.

Therefore, the secondary coil provides a **smaller voltage and a larger current** than the primary.

The correct answer is **(b)**: a smaller voltage and a larger current than the primary.

Question 21

Commercial electric power is sent across country using high voltage transmission lines. If low voltage transmission lines were used instead, those low voltage lines would:

- **(a)** have to use direct current, which would not operate most equipment properly.
- **(b)** not be magnetic enough to transform electricity efficiently into energy.
- **(c)** have to be placed closer to the ground, where they would be more hazardous.
- **(d)** have to be made of thicker metal, which would be expensive.

Solution:

To reduce energy loss due to resistance, high voltage lines are used. If low voltage lines were used, the current would be higher, requiring thicker wires to prevent overheating.

The correct answer is **(d)**: have to be made of thicker metal, which would be expensive.

Question 22

Electric power passes through a nearby power transformer on its way to your home. The current that enters your home actually receives its power as it passes through the secondary coil of that transformer. Doubling the number of turns in the secondary coil would:

- **(a)** halve the voltage available at your home.
- **(b)** double the frequency (cycles-per-second) of the alternating current entering your home.
- **(c)** double the voltage available at your home.
- **(d)** halve the frequency (cycles-per-second) of the alternating current entering your home.

Solution:

Doubling the number of turns in the secondary coil increases the voltage by a factor of two:

$$V_s = V_p \times \frac{N_s}{N_p}$$

The correct answer is **(c)**: double the voltage available at your home.

Answer Key

1. **(a)** attract each other
2. **(b)** -2C
3. **(d)** the distance between the garments increases
4. **(d)** (a) and (b)
5. **(c)** use corona discharge to bleed off local charge accumulations
6. **(d)** light
7. **(c)** sharp and pointed
8. **(c)** electrons can take a short cut
9. **(c)** no current will flow at all and the bulb will not light up
10. **(a)** zero
11. **(a)** a current must flow through it across a voltage decrease
12. **(b)** the light bulb consumes 100 J of energy per second
13. **(a)** 288W
14. **(a)** 5.0 Ω
15. **(b)** That arrangement is unstable—the upper magnet will fall to the side or flip over
16. **(b)** They easily lose their magnetization
17. **(d)** current induced in the aluminum by the approaching north pole produces a repelling north pole on the aluminum's surface
18. **(a)** always attract
19. **(b)** there need to be enough thermal fluctuations to disorient the magnetic domains and cause the rock to be magnetic
20. **(b)** a smaller voltage and a larger current than the primary
21. **(d)** have to be made of thicker metal, which would be expensive
22. **(c)** double the voltage available at your home