Electromagnetic spectrum worksheet

This unique NASA resource on the web, in print, and with companion videos introduces electromagnetic waves, their behaviors, and how scientists visualize these data. Each region of the electromagnetic spectrum (EMS) is described and illustrated with engaging examples of NASA science. Come and explore the amazing world beyond the visible! Introduction to the Electromagnetic Spectrum: Electromagnetic energy travels in waves and spans a broad spectrum from very long radio waves to very short gamma rays. You depend on electromagnetic energy every hour of every day. Without it, the world you know could not exist. Anatomy of an Electromagnetic Wave: An electromagnetic wave is made up of changing electric and magnetic fields and is important way that energy is transported in the world around us. Wave Behaviors: Light waves across the electromagnetic spectrum behave in similar ways and can be transmitted, reflected, absorbed, refracted, polarized, diffracted, or scattered depending on the composition of an object the wave encounters. Visualization: From Energy to Image: Electromagnetic energy is observed and recorded by satellites and then transmitted to Earth. These data, including data from beyond the visible spectrum, are processed into images. Radio Waves: The longest wavelengths in the spectrum, Radio waves can carry tunes from a radio station or be emitted from astronomical objects like from the Sun's corona. Microwaves: Microwaves penetrate through clouds, dust, smoke, snow, and rain making them ideal for communications satellites. They are also used in active and passive science instruments to study the Earth and the night sky. Infrared Waves: Light waves just beyond the visible spectrum of light are infrared light waves. They range from near-infrared like what are used in remote controls, to far-infrared which can be sensed as heat. Reflected Near-Infrared Waves: Scientists can study how objects reflect, transmit, and absorb the Sun's near-infrared radiation to observe health of vegetation and soil composition. Visible Light: All electromagnetic radiation is light, but we can only see a small portion of this radiation—the portion we call visible light. Ultraviolet Waves: The Sun is a source of the full spectrum of ultraviolet radiation and most of this radiation is blocked by the atmosphere. Scientists study stars and galaxies in the ultraviolet as well as the composition of Earth's atmosphere. X-Rays: X-rays have much higher energy and the Earth's atmosphere protects us from these harmful rays. Scientists use satellites to observe x-ray radiation coming from galaxies and stars like our Sun. Gamma Rays: Gamma rays have the most energy of any wave in the electromagnetic spectrum and are produced by the hottest and most energetic objects in the universe. Earth's Radiation Budget: The energy entering, reflected, absorbed, and emitted by the Earth system are the components of the Earth's radiation budget. Determine the following quantities for each of the two circuits shown below… the equivalent resistance the current from the power supply the current through each resistor the voltage drop across each resistor the power dissipated in each resistor Follow the rules for series circuits. Resistances in series add up. RT = R1 + R2 + R3 RT = 20 Ω + 30 Ω + 50 Ω RT = 100 Ω Total current is determined by the voltage of the power supply and the equivalent resistance of the circuit. IT = VT/RTIT = 125 V/100 ΩIT = 1.25 A Current is constant through resistors in series. IT = I1 = I2 = I3 = 1.25 A The voltage drops can be found using Ohm's law. V1 = I1R1V1 = (1.25 A)(20 Ω)V1 = 25.0 V V2 = I2R2V2 = (1.25 A)(30 Ω)V2 = 37.5 V V3 = I3R3V3 = (1.25 A)(50 Ω)V3 = 62.5 V Verify your calculations by adding the voltage drops. On a series circuit they should equal the voltage increase of the power supply. VT = V1 + V2 + V3 125 V = 25.0 V + 37.5 V + 62.5 V 125 V = 125 V We're good, so let's finish. There are three equations for determining power. Since we have three resistors, let's apply a different equation to each as an exercise. P1 = V1 I1P1 = (25.0 V)(1.25 A)P1 = 31.250 W P2 = I22R2P2 = (1.25 A)2(30 Ω)P2 = 46.875 W P3 = V32/R3P3 = (62.5 V)2/(50 Ω)P3 = 78.125 W In a series circuit, the element with the greatest resistance consumes the most power. Follow the rules for parallel circuits. Resistances in parallel combine according to the sum-of-inverses rule. 1 = 1 + 1 + 1 RT R1 R2 R3 1 = 1 + 1 + 1 RT 20 Ω 100 Ω 50 Ω 1 = 5 + 1 + 2 RT 100 Ω 100 Ω 100 Ω 1 = 8 RT 100 Ω RT = 100 Ω = 12.5 Ω 8 Total current is determined by the voltage of the power supply and the equivalent resistance of the circuit. IT = VT/RTIT = 125 V/12.5 ΩIT = 10 A (Note: we'll answer part iv before part iii.) On a parallel circuit, each branch experiences the same voltage drop. VT = V1 = V2 = V3 = 125 V The current in each branch can be found using Ohm's law. I1 = V1/R1I1 = (125 V)/(20 Ω)I1 = 6.25 A I2 = V2/R2I2 = (125 V)/(100 Ω)I2 = 1.25 A I3 = V3/R3I3 = (125 V)/(50 Ω)I3 = 2.50 A Verify your calculations by adding the currents. On a parallel circuit they should add up to the current from the power supply. IT = I1 + I2 + I3 10 A = 6.25 A + 1.25 A + 2.50 A 10 A = 10 A Good, it works. Again as an exercise, use a different equation to determine the electric power of each resistor. P1 = V1I1P1 = (125 V)(6.25 A)P1 = 781.25 W P2 = I22R2P2 = (1.25 A)2(100 Ω)P2 = 156.25 W P3 = V32/R3P3 = (125 V)2/(50 Ω)P3 = 312.50 W In a parallel circuit, the element with the least resistance consumes the most power. A kitchen in North America has three appliances connected to a 120 V circuit with a 15 A circuit breaker: an 850 W coffee maker, a 1200 W microwave oven, and a 900 W toaster. Draw a schematic diagram of this circuit. Which of these appliances can be operated simultaneously without tripping the circuit breaker? Outlets are wired in parallel so that the appliances on a circuit are independent of one another. Turning the coffee maker off will not result in the toaster turning off (assuming both were on at the same time). Each appliance will also get the same regulated voltage, which simplifies the design of electrical devices. The downside to this scheme is that the parallel currents can add up to dangerously high levels. A circuit breaker in series before the parallel branches can prevent overloads by automatically opening the circuit. A 15 A circuit operating at 120 V consumes 1,800 W of total power. P = VI = (120 V)(15 A) = 1,800 W Total power in a parallel circuit is the sum of the power consumed on the individual branches. coffee maker + microwave oven 850 W + 1200 W 2050 W microwave oven + toaster 1200 W + 900 W 2100 W toaster + coffee maker 900 W + 850 W 1750 W On this circuit, only the coffee maker and toaster can be operated simultaneously. All other combinations will trigger the circuit breaker to open. The diagram below shows a circuit with one battery and 10 resistors; 5 on the left and 5 on the right. Determine… the current through the voltage drop across the power dissipated by each resistor The way to solve a complex problem is to break it down into a series of simpler problems. Be careful not to lose sight of your goal among all the bits and pieces, however. Before beginning plot your course. In this case we'll start by finding the effective resistance of the entire circuit and the current from the battery. This sets us up to get the current in all the different segments of the circuit. (The current divides and divides again in an effort to follow the path of least resistance.) After that, it's a simple matter to calculate the voltage drops in each resistor using V = IR and the power dissipated using P = VI. No part of this problem is difficult by itself, but since the circuit is so complex we'll be quite busy for a little while. Let's begin the process by combining resistors. There are four series pairs in this circuit. left Rs = 3 Ω + 1 ΩRs = 4 ΩRs = 4 Ω + 2 ΩRs = 6 Ω right Rs = 2 Ω + 3 ΩRs = 5 ΩRs = 1 Ω + 4 ΩRs = 5 Ω These pairs form two parallel circuits, one on the left and one on the right. left right Each gang of four resistors is in series with another. left Rs = 2.4 Ω + 0.6 ΩRs = 3 Ω right Rs = 2.5 Ω + 0.5 ΩRs = 3 Ω The left and right halves of the circuit are parallel to each other and to the battery. 1 = 1 + 1 = 2 Rp 3 Ω 3 Ω 3 Ω Now that we have the effective resistance of the entire circuit, let's determine the current from the power supply using Ohm's law. Itotal = Vtotal + 24 V = 16 A Rtotal 1.5 Ω Now walk through the circuit (not literally of course). At each junction the current will divide with more taking the path with less resistance and less taking the path with more resistance. Since charge doesn't leak out anywhere on a complete circuit, the current will be the same for all those elements in series with one another. The left and right halves of the circuit are identical in overall resistance, which means the current will divide evenly between them. 8 A for the 0.6 Ωresistor on the left. 8 A for the 0.5 Ωresistor on the right. On each side the current divides again into two parallel branches. The branches on the left have resistances in the ratio… R1&3 = 4 Ω + 2 R2&4 6 Ω 3 which means the currents will divide in the ratio… for the 1 Ω and 3 Ωresistors on the left. for the 2 Ω and 4 Ωresistors on the left. The branches on the right are identical, so the current splits into two equal halves. ☟☟☟☟☟ for the 2 Ω and 3 Ωresistors on the right. for the 1 Ω and 4 Ωresistors on the right. Use V = IR over and over and over again to determine the voltage drops. (See the tables at the end of this solution.) Use P = VI (or P = I2R or P = V2/R) over and over again to determine the power dissipated. These last two tasks are so tedious you should use a spreadsheet application of some sort. Enter the resistance values given and the current values just calculated into columns and instruct your electronic device of choice to multiply appropriately. Something like this… Left side resistance(Ω) current(A) voltage(V) power(W) 0.6 8.0 04.8 38.40 1.0 4.8 04.8 23.04 2.0 3.2 06.4 20.48 3.0 4.8 14.4 69.12 4.0 3.2 12.8 40.96 Right side resistance(Ω) current(A) voltage(V) power(W) 0.5 8 04 32 1.0 4 04 16 2.0 4 08 32 3.0 4 12 48 4.0 4 16 64 Given the circuit below… Calculate the equivalent resistance of the circuit. Calculate the current through the battery. Graph voltage as a function of location on the circuit assuming that Va = 0 V at the negative terminal of the battery. Graph current as a function of location on the circuit. Here are the solutions… The total resistance in a series circuit is the sum of the individual resistances… RT = R1 + R2 + R3RT = 3 Ω + 9 Ω + 6 ΩRT = 18 Ω The total current can be found from Ohm's law… IT = VT/RTIT = (12 V)/(18 Ω) = ⅔ AIT = 0.667 A The voltage in a circuit rises in a battery and drops in a resistor (when we follow the flow of conventional current). The rise in the battery is given as 12 V and the drops in each resistor can be found through repeated use of Ohm's law… V1 = I1R1V1 = (⅔ A)(3 Ω)V1 = 2 V V2 = I2R2V2 = (⅔ A)(9 Ω)V2 = 6 V V3 = I3R3V3 = (⅔ A)(6 Ω)V3 = 4 V Starting at zero volts on the negative terminal of the battery, the voltage goes up 12 V then drops 2 V, 6 V, and 4 V, which brings us back to zero. (We are assuming that the battery and wires have negligible resistance.) Here's how it looks when graphed. Here's how it looks when the graph is superimposed on the circuit. Current is everywhere the same in a series circuit. We've already determined it's 0.667 A. All that remains is to draw a horizontal line at two-thirds of an amp. Here's how it looks when the graph is superimposed on the circuit.

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