

# Physics 106 Final Exam

Name: \_\_\_\_\_ UMich unickname: \_\_\_\_\_

- **open book:** prelabs, worksheets, exams, homeworks, non-programmable calculator are allowed.
- **questions** are of equal value; “choose all” questions are graded like set of yes/no questions.
- **time:** 90 minutes

1. You stand on the edge of Argo pond, which has completely frozen over. You drop a rock on the ice directly next to you, and you hear a solid “thump” (the familiar sound of a rock hitting something). However, when you lob the rock about 20 meters away from you towards the center of the lake, and it hits the ice, you hear a “biiiiuuuu” sound (a sound that starts off at a high pitch and then gets low). Explain why the sound you hear **is different** depending on where you drop the rock:

2. A friend urges you to stop eating bananas because they are (naturally) radioactive.

(a) Assume you are eating an average of **one banana a day**. What is the total radiation dose you get in **one year**?

$H =$  \_\_\_\_\_

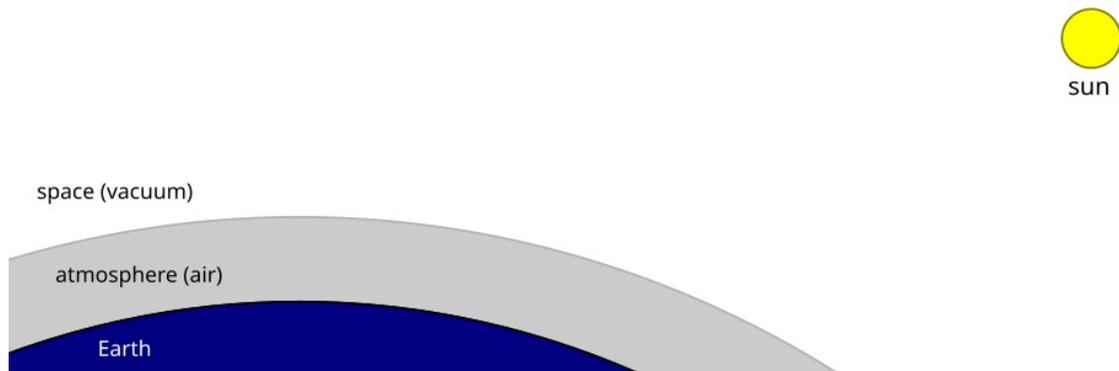
(b) Follow-up: Does your friend need to worry about the radioactivity of bananas? Why or why not?

3. You have 200g of vodka at  $0^{\circ}\text{C}$  in a thermally insulated container. You add 200g of boiling water at  $100^{\circ}\text{C}$ . After you stir thoroughly, the temperature of the water–vodka mixture is  $65^{\circ}\text{C}$ . Which of the following statements are true? (**Choose all that apply**)

- (a) The thermal energy lost by the water is **less** than the thermal energy gained by the vodka.
- (b) The thermal energy lost by the water is **equal** to the thermal energy gained by the vodka.
- (c) The specific heat of water is **greater** than the specific heat of vodka.
- (d) The specific heat of water is **equal** to the specific heat of vodka.
- (e) The specific heat of water is **less** than the specific heat of vodka.

4. Below, you see a diagram of Earth and the sun (obviously not to scale). The Earth is surrounded by an atmosphere made of air. Outside of the atmosphere is space (vacuum).

- (a) Sketch a ray of sunlight as it passes from the sun to the Earth. You can assume that the atmosphere has a constant density throughout.



(b) Follow-up: now think of yourself, standing on the surface of the Earth, and observing the sun. Which of the following statements is true? (**Choose one**)

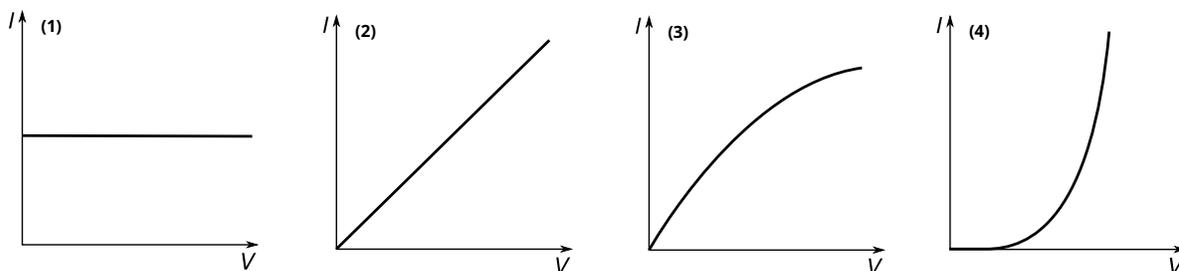
- a) The bottom of sun appears to be touching the horizon.
- b) The sun appears slightly higher above the horizon than it actually is.
- c) The sun appears slightly lower above the horizon than it actually is.
- d) The sun appears in the zenith (directly above the observer).
- e) The sun appears exactly where it actually is.

5. Below, I have plotted the current ( $I$ ) over the voltage ( $V$ ) for different devices. **Match** the following devices to their respective graph.

(a) Ideal resistor: \_\_\_\_\_

(b) LED: \_\_\_\_\_

(c) Incandescent light bulb: \_\_\_\_\_



6. Standing waves in a room behave very similar to standing waves on a string. Assuming a speed of sound in air of **340 m/s**, what is the frequency of the lowest tone that can produce a standing wave in a room that is **5 meters** across? (**choose one**)

(a) 5 Hz

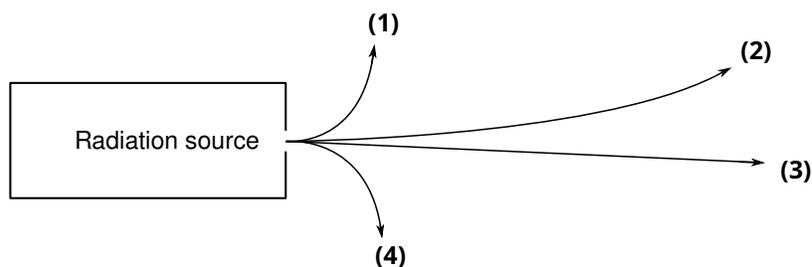
(b) 17 Hz

(c) 34 Hz

(d) 68 Hz

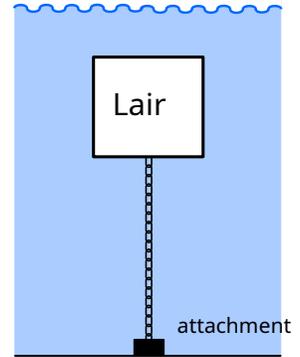
(e) 1700 Hz

7. You have a radiation source depicted below. You have applied a strong **magnetic field**, such that the north pole is above the paper and the south pole is below the paper and the magnetic field lines run from you through the paper into your desk. **Assign** types of radiation (alpha, beta+, beta-, gamma) to each of the tracks (1, 2, 3, 4).

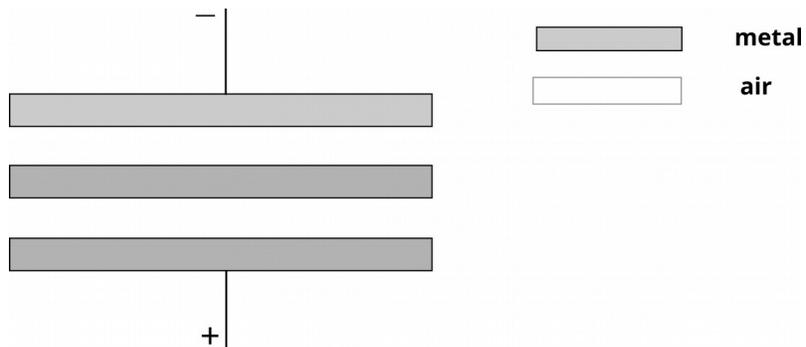


8. Your love for James Bond villains inspires you to construct an underwater lair. You aim for a box of 2 x 2 x 2 meters, and calculate the weight of the building materials as 500 kg. You plan to attach the lair to the bottom using a chain. How strong is the force tugging on the attachment? (Hint: 1 m<sup>3</sup> = 1000 L)

$$F = \underline{\hspace{10em}}$$

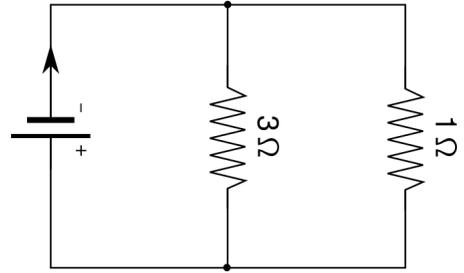


9. Depicted below is a design for a capacitor. Indicate the location of the positive and negative charges when it is fully charged.



10. You have two compasses about 20 cm away from each other. Each compass' North is pointing towards the other compass. What can you conclude? (**choose all that apply**)
- (a) There is the south pole of another magnet between the two compasses.
  - (b) There is the north pole of another magnet between the two compasses
  - (c) The compasses' north poles are attracted to each other by the magnetic force.
  - (d) The compass needles are aligned perpendicular to the magnetic field lines
  - (e) The compass needles are aligned with the magnetic field lines

11. Look at the circuit diagram on the right. Which of the following statements are true? (**choose all that apply**)



- (a) The voltage across the 3Ω resistor is three times as large as the voltage across the 1Ω resistor
- (b) The voltage across the 3Ω resistor is the same as the voltage across the 1Ω resistor
- (c) The current through the 3Ω resistor is three times as large as the current through the 1Ω resistor
- (d) The current through the 3Ω resistor is the same as the current through the 1Ω resistor
- (e) The current through the 1Ω resistor is three times as large as the current through the 3Ω resistor

12. You are planning a camping trip and you are thinking about using a solar cell to make tea.

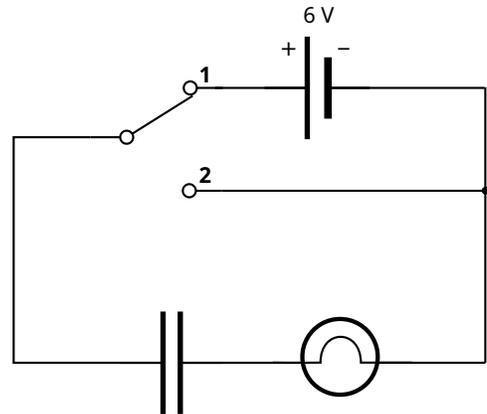
- (a) The specific heat of water is  $C = 4 \text{ J/(g } ^\circ\text{C)}$ . How much electrical power  $P$  do you need to heat up a cup (200g) of water from  $20^\circ\text{C}$  to  $100^\circ\text{C}$  in 10 minutes (600 s)?

$P =$  \_\_\_\_\_

- (b) Follow-up: Bright daylight has an illuminance of about  $150 \text{ W/m}^2$  ( $100,000 \text{ L/m}^2$ ). Your solar cell has an efficiency of 20%. How large must the illuminated area  $A$  of your solar cell be, if you want to supply the power needed for point (a)?

$A =$  \_\_\_\_\_

13. You build the circuit according to the circuit diagram to the right. Which of the following statements are true? (**choose all that apply**)

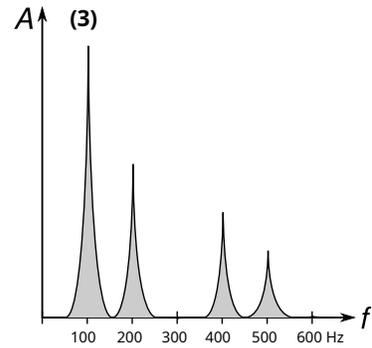
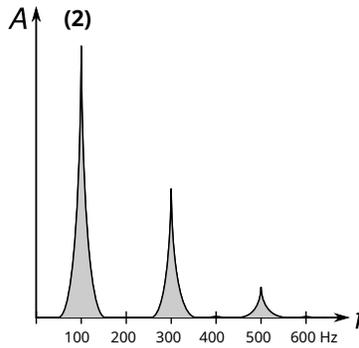
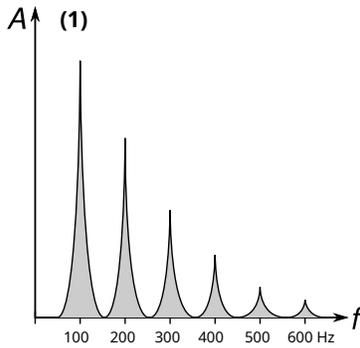


- (a) Setting 1: While the capacitor is charging, the light bulb will slowly get dimmer.
- (b) Setting 1: When the capacitor is fully charged, the voltage across the light bulb will be 6 V.
- (c) Setting 2: When the capacitor is fully charged, the voltage across the light bulb will be 6 V.
- (d) Setting 2: While the capacitor is discharging, the light bulb will slowly get dimmer.
- (e) Setting 2: When the capacitor is fully discharged, the current is zero.

14. You record the spectrum of different musical instruments playing a tone with a frequency of 100 Hz. Match the different instruments to the spectra:

(a) organ pipe: \_\_\_\_\_

(b) guitar: \_\_\_\_\_



15. You are standing in front of a (plane) mirror.

(a) Draw yourself and the mirror twice, once from the side (where you appear in profile), and once from a bird's eye view. Draw rays of light from different parts of your body as they are reflected by the mirror and enter your eye.

(b) Follow-up: Your mirror image looks back at you with their left side being your right side and vice-versa. If left side and right side are exchanged, why isn't your mirror image also upside down?

*Gutes Gelingen!*