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2. You have a Carnot engine operating reversibly between a furnace at  $527^{\circ}\text{C}$  and the outside on a summer day, at about  $27^{\circ}\text{C}$ . The furnace is powering an air conditioning unit for a large building that uses 40 kW of power. How much power is ejected as exhaust to the outside?

- A) 48 kW.
  - B) 18 kW.
  - C) 64 kW.
  - D) 24 kW. ✓
  - E) 40 kW.
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7. Asphalt has a specific heat of around  $900 \text{ J/kg/K}$  and a density of  $2000 \text{ kg/m}^3$ . Consider a UCSD parking lot (made of asphalt) that is square,  $200 \text{ m}$  on a side, and  $.25 \text{ m}$  thick. Sunlight of intensity  $1 \text{ kW/m}^2$  is incident on the parking and heats it up during our “winter” months. How long does it take to heat the parking lot up from its temperature during the night, around  $0^\circ \text{ C}$ , to its daytime temperature, around  $30^\circ \text{ C}$ ?

- A)  $24000 \text{ s}$  (6 hrs, 40 min).
- B)  $5400 \text{ s}$  (1 hrs, 30 min).
- C)  $8100 \text{ s}$  (2 hrs, 15 min).
- D)  $17100 \text{ s}$  (4 hrs, 45 min).
- E)  $13500 \text{ s}$  (3 hrs, 45 min). ✓

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8. Consider our favorite  $1.8 \text{ kg}$  cube of side  $.1 \text{ m}$  hanging on a string. As usual, I pluck the string with the cube hanging in air and hear a tone of  $100 \text{ Hz}$ . To commemorate my new home, I now put the cube in big vat of olive oil and pluck the string again. Now I hear a frequency of  $50 \text{ Hz}$ . What is the density of the olive oil?

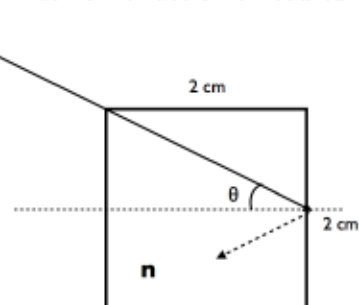
- A) 1.15 times the density of water.
- B) 1.80 times the density of water.
- C) 1.60 times the density of water.
- D) 1.50 times the density of water.
- E) 1.35 times the density of water. ✓

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9. The T-rex dinosaur in Robert Mukdoon’s side-view mirror, which is a convex mirror with a focal length of  $-50 \text{ cm}$ , appears to be only  $3 \text{ m}$  tall. Mukdoon knows the T-rex is right on their tail, about  $2.5 \text{ m}$  back from the mirror. How tall does he deduce the T-rex to actually be in this terrifying situation?

- A)  $25 \text{ m}$ .
  - B)  $6 \text{ m}$ .
  - C)  $18 \text{ m}$ . ✓
  - D)  $30 \text{ m}$ .
  - E)  $10 \text{ m}$ .
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11. You shine laser light from air through the corner of a cube of side 2 cm made of lead tungstate ( $\text{PbWO}_4$ ) onto the other side of the cube. When the laser light hits the center of that opposing face (see figure, it should look familiar) the light totally internally reflects. What is the index of refraction of lead tungstate?



- A)  $n = \sqrt{3}$ .
  - B)  $n = \sqrt{2}$ .
  - C)  $n = \frac{\sqrt{5}}{2}$ .
  - D)  $n = \sqrt{5}$ . ✓
  - E)  $n = 2$ .
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13. Treating your eyeball as a circular aperture  $5 \approx 4.88$  mm in diameter (for the pupil), what is the smallest object you could *possibly* make out at your feet? Assume you are typical human, 1.5 m tall, and that you are looking with green light (the peak wavelength of the sun at 500 nm).

- A) About .2 mm. ✓
  - B) About .003 mm.
  - C) About 30 mm.
  - D) About .06 mm.
  - E) About 4 mm.
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14. The fundamental frequency of a pipe is 100 Hz. Which of the following pairs of frequencies would be the next harmonic (above the fundamental) if the pipe were (open on one end, open on both ends)?

- A) (200, 200) Hz.
  - B) (300, 300) Hz.
  - C) (300, 200) Hz. ✓
  - D) (200, 150) Hz.
  - E) More than one of these answers is possible.
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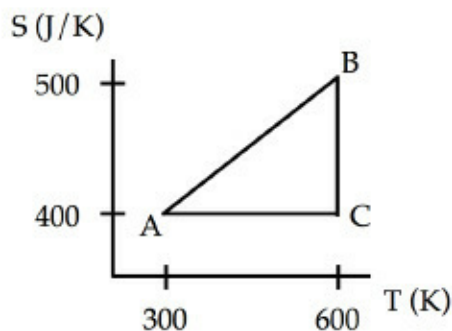
15. In a plasma physics experiment on the 5<sup>th</sup> floor of Mayer Hall unpolarized laser light of intensity  $I_0$  passes through 4 polarizers. Each successive polarizer has its transmission axis oriented at a  $60^\circ$  angle relative to the previous one so that the final polarizer's transmission axis is inverted (at  $180^\circ$ ) relative to the first one's. What is the intensity of light after passing through the four polarizers?

- A)  $\frac{3I_0}{32}$ .
  - B)  $\frac{I_0}{128}$ . ✓
  - C)  $\frac{81I_0}{512}$ .
  - D)  $\frac{9I_0}{64}$ .
  - E)  $I_0$ .
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17. A small child playing with a bubble toy initially sees the bubble with a red sheen that changes to a blue sheen in the bubble just as it pops. By how much did the bubble's thickness **change** before it popped, treating the bubble as water ( $n = 1.5$ )?

- A) 300 nm.
  - B) 75 nm.
  - C) 175 nm.
  - D) 50 nm. ✓
  - E) 100 nm.
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18. Consider the plot of an engine cycle drawn in the  $T - S$  plane. How much work does the engine do in a cycle if it goes from A to B to C?. [Hint: Start from  $dS = \frac{dQ}{T}$  and  $\Delta U$  for an entire cycle.]



- A) 4 kJ.
  - B) 3 kJ.
  - C) 12 kJ.
  - D) 15 kJ. ✓
  - E) Need to know how much heat is added during the processes.
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19. Some amount of a hydrocarbon is combusted to add 3500 J of heat to nitrogen, a diatomic ideal gas. The nitrogen is in a piston that can expand but is kept at atmospheric pressure. How much of the heat is used to expand the gas?

- A) 500 J.
  - B) 2100 J.
  - C) 0 J.
  - D) 1000 J. ✓
  - E) 1400 J.
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21. Our favorite ant Klyde has a cousin, Mlyde (he's Irish), that has a sensitive stomach— he can't experience  $g$ -forces (accelerations) larger than  $g$  ( $= 10 \text{ m/s}^2$ ). Mlyde is riding on a string down which we send a wavetrain with waveform  $y(x, t) = A \sin(5x - 4t)$ . All values are in SI units. What is the maximum amplitude we can give to the wavetrain we send to Mlyde, without causing him to vomit?

- A)  $A_{\text{max}} = 0.63 \text{ m}$ . ✓
  - B)  $A_{\text{max}} = 2.5 \text{ m}$ .
  - C)  $A_{\text{max}} = 0.2 \text{ m}$ .
  - D)  $A_{\text{max}} = 2 \text{ m}$ .
  - E)  $A_{\text{max}} = 1.5 \text{ m}$ .
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22. You make a cup of tea but forget about it and leave it on the table. The tea eventually cools down to room temperature. Which of the following is true during this process?

- A)  $\Delta S_{\text{tea}} = 0$  and  $\Delta S_{\text{universe}} = 0$ .
  - B)  $\Delta S_{\text{tea}} < 0$  and  $\Delta S_{\text{universe}} = 0$ .
  - C)  $\Delta S_{\text{tea}} > 0$  and  $\Delta S_{\text{universe}} = 0$ .
  - D)  $\Delta S_{\text{tea}} > 0$  and  $\Delta S_{\text{universe}} > 0$ .
  - E)  $\Delta S_{\text{tea}} < 0$  and  $\Delta S_{\text{universe}} > 0$ . ✓
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24. Consider a double slit situation where the wavelength of some wave incident on the slits is the same as the slit separation (this could happen with ocean waves at two entrances to a harbor, for example). At what angle from the central maximum will you see the first dark/low spot?

- A)  $30^\circ$ . ✓
  - B)  $60^\circ$ .
  - C)  $45^\circ$ .
  - D) An angle less than  $30^\circ$  (can't compute without calculator).
  - E) You will not observe a full interference pattern with this configuration.
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