30 November 2003

Instructions: Please answer each question. In questions that require written answers use complete sentences. For any problems requiring a calculation show your work and include the units used. Put a box around any final answers.

Part I. Short questions.

1. (5 pts) Why is water a popular choice as a heat storing material in solar heating systems?

2. (5 pts) When lightning strikes some distance away you see the flash of the lightning before you hear the thunder. Why is there a time lag between the two?

3. (5 pts) Diamond's index of refraction is 2.42. What is the speed that light travels in diamond?

4. (5 pts) Convert a temperature of 20 °C into Fahrenheit.

5. (5 pts) More than half the heat generated in a coal fired power plant is not converted into electricity. What physical law explains why the conversion can't be 100% efficient?
6. (5 pts) How are transverse and longitudinal waves different?

7. (5 pts) A "concert A" musical note has a frequency of 440 Hz. What is the wavelength of this note as it travels through air?

8. (5 pts) Diffuse scattering of light from a surface means incoming light, even if in parallel rays, is scattered in many directions. Does this violate the "angle of incidence equals angle of reflection" law? Explain.

9. (5 pts) How much heat would it take to raise 500 grams of water at 20 °C to a temperature of 100 °C?

10. (5 pts) If we hear a particular note played on a violin and the same note played on an organ, we can tell what instrument played the note. What provides the audio information that lets us tell the difference between these instruments?
Part II. Longer Questions. Again, show your work and/or use complete sentences.

11. (10 pts) A sample of gas is contained in a cylinder with a movable piston. Heat is added to the gas which causes temperature of the gas to double while the pressure of the gas does not change.

A) Compared to the original volume occupied by the gas, what is the new volume?

B) In terms of the kinetic theory of gases, what happened to the average kinetic energy of the gas molecules in the situation described above?

12. (15 pts) Waves on a lake have a wavelength of 1.5 m, an amplitude of 0.35 m, and a period of 0.80 s.

A) What is the frequency of these waves?

B) What is the wave speed?

C) If the amplitude of the water waves doubled, would it change your answer to part A) or B)? Explain.
13. (15 pts) For each of the lens and mirror situations shown, carefully draw in the appropriate rays to locate the image. Label the image location and whether the image is real or virtual.

A) Mirror

B) Lens

14. (10 pts) When you load a slide projector, slides are put in upside down.

A) Is the image on the screen a real or virtual image? How do you know?

B) Why are the slides put in upside down?
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Instructions: Please answer each question. In questions that require written answers use complete sentences. For any problems requiring a calculation show your work and include the units used. Put a box around any final answers.

Part I. Short questions.

1. (5 pts) Why is water a popular choice as a heat storing material in solar heating systems?
   - It has a high specific heat capacity - it can store a lot of energy for a given temperature increase.

2. (5 pts) When lightning strikes some distance away you see the flash of the lightning before you hear the thunder. Why is there a time lag between the two?
   - The speed at which sound waves (thunder) is much less than the speed of light (lightning).

3. (5 pts) Diamond’s index of refraction is 2.42. What is the speed that light travels in diamond?
   \[
   n = \frac{c}{c_{\text{nit}}} \quad \text{so} \quad \frac{c_{\text{nit}} \cdot n}{c_{\text{nit}}} = c, \quad c_{\text{nit}} = \frac{c}{n}
   \]
   \[
   c_{\text{nit}} = \frac{3.00 \times 10^8 \text{m/s}}{2.42} = \frac{1.24 \times 10^8 \text{m/s}}{}
   \]

4. (5 pts) Convert a temperature of 20 °C into Fahrenheit.
   \[
   T_F = 32 + \frac{9}{5} T_C = 32 + \frac{9}{5} (20 \degree C) = 68 \degree F
   \]

5. (5 pts) More than half the heat generated in a coal-fired power plant is not converted into electricity. What physical law explains why the conversion can’t be 100% efficient?
   - Not covered
6. (5 pts) How are transverse and longitudinal waves different?
With transverse waves, particles move perpendicular to the direction the wave travels (e.g. wave on a rope) while longitudinal waves have particles moving parallel to the wave travel (e.g. sound).

7. (5 pts) A "concert A" musical note has a frequency of 440 Hz. What is the wavelength of this note as it travels through air?
\[
\lambda = \frac{v}{f} = \frac{344 \text{ m/s}}{440 \text{ Hz}} = 0.78 \text{ m}
\]

8. (5 pts) Diffuse scattering of light from a surface means incoming light, even if in parallel rays, is scattered in many directions. Does this violate the "angle of incidence equals angle of reflection" law? Explain.
No - the surface is rough - each ray obeys angle of incidence equals angle of reflection, but the reflected rays are not parallel due to the surface tilt.

9. (5 pts) How much heat would it take to raise 500 grams of water at 20 °C to a temperature of 100 °C?
\[
H = mc\Delta T = 500 \text{ g} \times (1 \text{ cal/g °C}) (100 °C - 20 °C) = 40,000 \text{ cal}
\]

10. (5 pts) If we hear a particular note played on a violin and the same note played on an organ, we can tell what instrument played the note. What provides the audio information that lets us tell the difference between these instruments?
The overtones (higher harmonics) provide this information.
Part II. Longer Questions. Again, show your work and/or use complete sentences.

11. (10 pts) A sample of gas is contained in a cylinder with a movable piston. Heat is added to the gas which causes temperature of the gas to double while the pressure of the gas does not change.
A) Compared to the original volume occupied by the gas, what is the new volume?

B) In terms of the kinetic theory of gases, what happened to the average kinetic energy of the gas molecules in the situation described above?

12. (15 pts) Waves on a lake have a wavelength of 1.5 m, an amplitude of 0.35 m, and a period of 0.80 s.

A) What is the frequency of these waves?
\[ f = \frac{1}{T} = \frac{1}{0.80\text{s}} = \frac{1.25}{1.25} \text{ Hz} \]

B) What is the wave speed?
\[ v = \lambda \cdot f = (1.5\text{m}) \cdot (1.25\text{Hz}) = 1.88\text{m/s} \]

C) If the amplitude of the water waves doubled, would it change your answer to part A) or B)? Explain.
No - amplitude does not affect freq. or wavelength.
13. (15 pts) For each of the lens and mirror situations shown, carefully draw in the appropriate rays to locate the image. Label the image location and whether the image is real or virtual.

A) Mirror

B) Lens

14. (10 pts) When you load a slide projector, slides are put in upside down.

A) Is the image on the screen a real or virtual image? How do you know?

It is real - rays must actually come together for an image to be viewable.

B) Why are the slides put in upside down?

The image is inverted compared to the object.