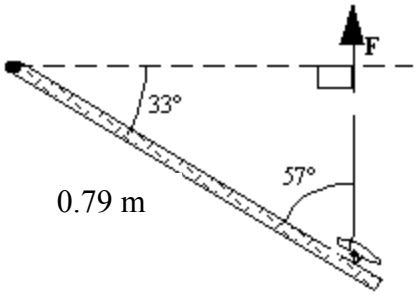
1. A string is tied to a doorknob 0.79 m from the hinge as shown in the figure. At the instant shown, the force applied to the string is 5.0 N. What is the torque on the door?

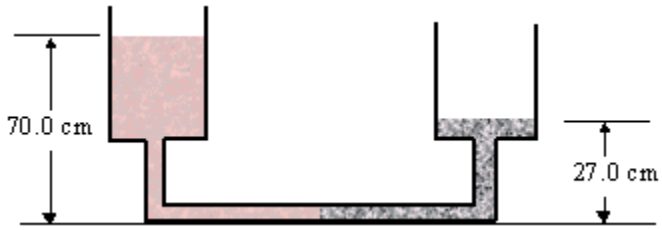


A) 3.3 N • m B) 2.2 N • m C) 1.1 N • m D) 0.84 N • m E) 0.40 N • m

2. Which one of the following statements concerning the moment of inertia *I* is false?
   A) *I* may be expressed in units of kg • m^2.
   B) *I* depends on the angular acceleration of the object as it rotates.
   C) *I* depends on the location of the rotation axis relative to the particles that make up the object.
   D) *I* depends on the orientation of the rotation axis relative to the particles that make up the object.
   E) Of the particles that make up an object, the particle with the smallest mass may contribute the greatest amount to *I*.

3. The two dams are identical with the exception that the water reservoir behind dam **A** extends twice the horizontal distance behind it as that of dam **B**. Which one of the following statements regarding these dams is correct?
   A) The force exerted by the water on dam **A** is greater than that on dam **B**.
   B) The force exerted by the water on dam **B** is greater than that on dam **A**.
   C) Dam **A** is more likely to collapse than dam **B** if the water level rises.
   D) Dam **B** is more likely to collapse than dam **A** if the water level rises.
   E) The horizontal distance of the water behind the two dams does not determine the force on them.

4. A column of water of height 70.0 cm supports a column of an unknown liquid as suggested in the figure (not drawn to scale). Assume that both liquids are at rest and that the density of water is 1.0×10^3 kg/m^3. Determine the density of the unknown liquid.



A) 3.9×10^2 kg/m^3 D) 3.3×10^3 kg/m^3

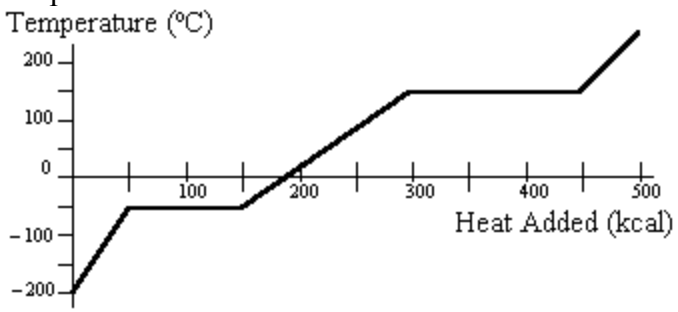
B) 1.2×10^3 kg/m^3
C) 2.6×10^3 kg/m^3
E) 3.9×10^3 kg/m^3

5. At a certain temperature, a simple pendulum has a period of 1.500 seconds. The support wire is made of silver and has a coefficient of linear thermal expansion of 1.90×10^{-5}/C°. How much must the temperature be increased to increase the period to 1.506 seconds?
A) 118 C° B) 221 C° C) 422 C° D) 316 C° E) 528 C°

6. Complete the following statement: The term *heat* most accurately describes
A) the internal energy of an object.
B) a measure of how hot an object is.
C) the absolute temperature of an object.
D) the molecular motion inside of an object.
E) the flow of energy due to a temperature difference.

Use the following to answer question 7:

Heat is added to a 1.0-kg solid sample of a material at –200 °C. The figure shows the temperature of the material as a function of the heat added.



7. Which one of the following statements concerning this substance is true?

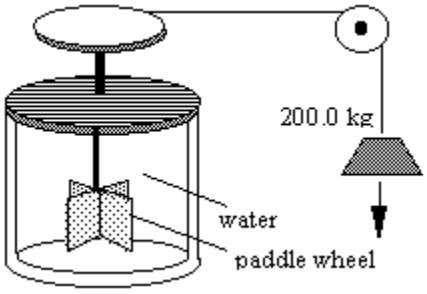
A) It boils at 300 °C.
B) It melts at –200 °C.
C) It is a liquid at 200 °C.
D) It can coexist as a solid and a liquid at –50 °C.

E) It can exist as a solid, liquid, and gas at 150 °C.

8. Two cylindrical steel rods **A** and **B** have radii of 0.02 m and 0.04 m, respectively. It is found that the two steel rods conduct the same amount of heat per unit time for the same temperature differences between their two ends. What is the ratio of the lengths of the rods, $L_{\mathbf{A}}/L_{\mathbf{B}}$?
   A) 0.25 B) 0.50 C) 1.00 D) 2.00 E) 4.00

9. An ideal gas is contained in a vessel with a moveable piston. Initially, the gas has a volume of 0.018 m^3, an absolute pressure of 1.5 atm, and a temperature of 30 °C. The pressure is 0.75 atm when the volume of the container is decreased to 0.009 m^3. What is the final temperature of the gas?
   A) 76 K B) 98 K C) 170 K D) 240 K E) 300 K

10. A 200.00-kg object is attached via an ideal pulley system to paddle wheels that are submerged in 0.480 kg of water at 20.0 C° in an insulated container as shown in the drawing. Then, the object fallls through a distance of 5.00 m causing the paddle wheel to turn. Assuming all of the mechanical energy lost by the falling object goes into the water, determine the final temperature of the water.

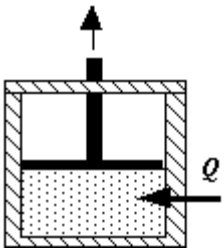


   A) 4.90 °C B) 20.5 °C C) 24.9 °C D) 40.4 °C E) 98.2 °C

11. Which one of the following situations is a direct application of the Zeroth Law of Thermodynamics?
   A) Block A has twice the temperature of block B before they are brought into contact. Upon contact, heat flows from block A to block B.
   B) A sample of gas within a cylinder with a piston is held at constant temperature and pressure while it is allowed to expand. During this process, the gas absorbs heat from its surroundings.
   C) The motor of a refrigerator uses electric energy to remove heat from inside the refrigerator and transfer it to the room.
   D) A physicist removes energy from a system in her laboratory until it reaches a temperature of 3×10^{-10} K, a temperature very close to (but still greater than) absolute zero.

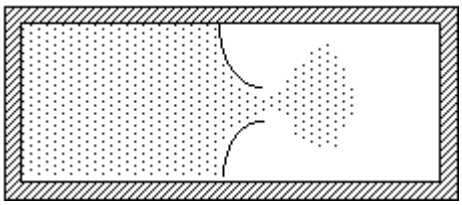
E) A thermometer is calibrated by placing it in an ice water bath within an adiabatic container until the thermometer is in thermal equilibrium with the ice water.

12. Enclosed beneath the moveable piston in the figure is 4.8 moles of a monatomic ideal gas. The gas performs work on the piston as 2300 J of heat are added from the surroundings. During the process, the temperature of the gas decreases by 45 K. How much work does the gas perform?



A) 5000 J B) 3200 J C) 1400 J D) 600 J E) 400 J

13. A thermally isolated sample of an ideal gas at a fixed temperature is confined to one half of a container by an impermeable membrane. The other half of the container is evacuated. The membrane is then pierced and the gas is allowed to expand freely and to double its volume as shown. Which one of the following statements is true concerning this situation?

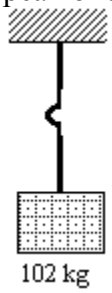


A) The process is reversible.
B) This is an isothermal process.
C) The entropy of the gas decreases.
D) The internal energy of the gas must decrease.
E) The temperature of the gas decreases to one-half of its original value.

14. A fixed amount of ideal gas is compressed adiabatically. Which entry in the table below correctly depicts the *sign* of the *work done*, the *change in the internal energy*, and the *heat exchanged* with the environment?

	work done	*change in internal energy*	*heat exchanged*
A)	positive	negative	zero
B)	negative	zero	positive
C)	negative	negative	zero
D)	positive	positive	zero
E)	negative	positive	zero

15. A steel wire of mass 0.400 kg and length 0.640 m supports a 102-kg block. The wire is struck exactly at its midpoint causing a small displacement. How long does it take the peak of this displacement to reach the top of the wire?

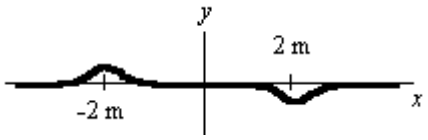


A) 2.00×10^{-3} s
B) 4.00×10^{-3} s
C) 6.00×10^{-3} s
D) 8.00×10^{-3} s
E) 1.60×10^{-2} s

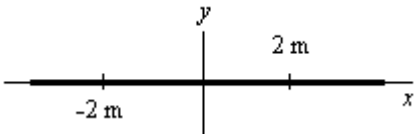
16. A transverse periodic wave described by the expression

(where y and x are in meters and t is in seconds) is established on a string. Which one of the following statements concerning this wave is false?
A) The wave is traveling in the negative x direction.
B) The amplitude is 1.0 m.
C) The frequency of the wave is 0.10 Hz.
D) The wavelength of this wave is 2.0 m.
E) The wave travels with speed 5.0 m/s.

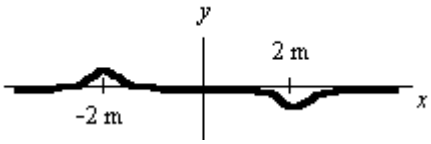
17. Two traveling pulses on a rope move toward each other at a speed of 1.0 m/s. The waves have the same amplitude. The drawing shows the position of the waves at time $t = 0$ s. Which one of the following drawings depicts the waves on the rope at $t = 2.0$ s?



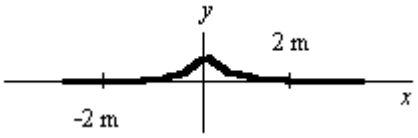
A)



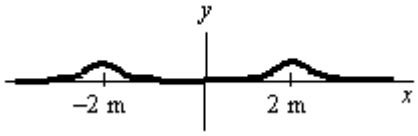
B)



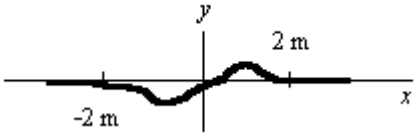
C)



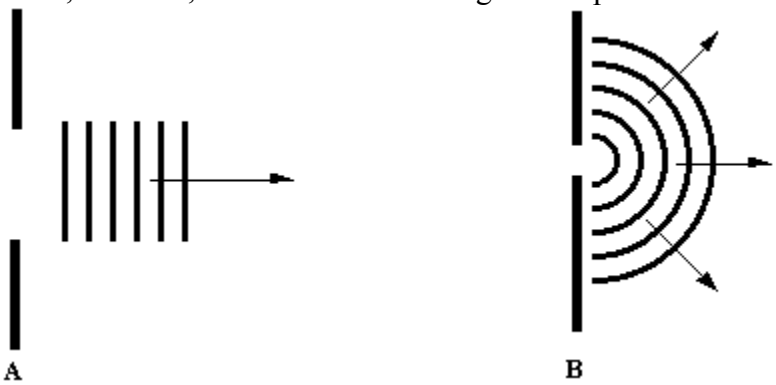
D)



E)



18. Water waves approach an aperture. The resulting patterns are shown for two different cases, **A** and **B**, in which the wavelength and aperture size are varied.



Which one of the following statements concerning these cases is true?

A) Neither figure shows diffraction. In both cases, the wavelength is much smaller than the aperture.
B) Diffraction occurs in **A**, but not in **B** because the wavelength in **A** is much smaller than the aperture.
C) Diffraction occurs in **B**, but not in **A** because the wavelength in **B** is much smaller than the aperture.
D) Both figures show diffraction. In both cases, the wavelengths are approximately the same size as the aperture.
E) Diffraction occurs in **B**, but not in **A** because the wavelength in **B** is approximately the same size as the aperture.

19. A 25-coil spring with a spring constant of 350 N/m is cut into five equal springs with five coils each. What is the spring constant of each of the 5-coil springs?

A) 14 N/m B) 70 N/m C) 350 N/m D) 700 N/m E) 1750 N/m

20. A vertical block-spring system on earth has a period of 6.0 s. What is the period of this same system on the moon where the acceleration due to gravity is roughly 1/6 that of earth?
A) 1.0 s B) 2.4 s C) 6.0 s D) 15 s E) 36 s

Answer Key -- FinalExam

1. A
2. B
3. E
4. C
5. C
6. E
7. D
8. A
9. A
10. C
11. E
12. A
13. B
14. E
15. D
16. E
17. A
18. E
19. E
20. C