

Q1.

A 3.60 m long stretched string has a mass of 0.180 kg. What average power must be supplied to the string to generate a sinusoidal wave having amplitude of 0.100 m, a wavelength of 0.500 m, and traveling with a speed of 30.0 m/s?

- A) 1.07 kW
- B) 2.13 kW
- C) 27.0 kW
- D) 4.26 kW
- E) 3.20 kW

Q2.

Two transverse sinusoidal waves, traveling on a string, are described by the wave functions

$$y_1(x, t) = 3.00 \sin[\pi(x + 0.600 t)]$$

$$y_2(x, t) = 3.00 \sin[\pi(x - 0.600 t)]$$

where  $x$ ,  $y_1$ , and  $y_2$  are in centimeters and  $t$  is in seconds. Determine the maximum transverse position of an element of the string at  $x = 0.250$  cm

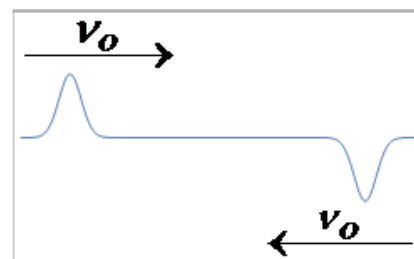
- A) 4.24 cm
- B) 2.12 cm
- C) 6.00 cm
- D) 2.40 cm
- E) 12.0 cm

Q3.

**Figure 1** shows two pulses, with equal but inverted amplitude, traveling on the same string toward each other. When the two pulses meet, they will

- A) Interfere destructively and then move away without changing the travel of each other
- B) Interfere destructively and then disappear
- C) Interfere constructively and then move away without changing the travel of each other
- D) Interfere constructively and then move as one large pulse
- E) Interfere constructively and then disappear

Figure 1



Q4.

A transverse wave is described by the wave function

$$y(x,t) = 10.0 \sin(2.00 x + 5.00 t)$$

where  $y$  and  $x$  are in meters and  $t$  is in seconds. The ratio of the transverse speed to the wave speed ( $u/v$ ) at  $x = 0$  and  $t = 0$  is:

- A) 20.0
- B) zero
- C) 50.0
- D) 10.0
- E) 100

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Q5.

A car with speed  $v_{car}$  and a bus with speed  $v_{bus}$  are heading straight toward each other, with  $v_{car} = 1.20 v_{bus}$ . The horn of the bus, with frequency  $f_{bus} = 2400$  Hz, is blowing and is heard to have a frequency of 3000 Hz by the driver in the car. Find the speed of the bus, in m/s, if the speed of sound is 340 m/s.

- A) 34.7
- B) 51.2
- C) 32.7
- D) 27.0
- E) 63.1

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Q6.

A standing wave is set up in an air-filled tube that is closed at one end. The standing wave has four nodes and the frequency of oscillation is 180 Hz. What is the length of the tube? (Speed of sound = 343 m/s)

- A) 3.33 m
- B) 6.66 m
- C) 7.62 m
- D) 2.22 m
- E) 1.90 m

Q7.

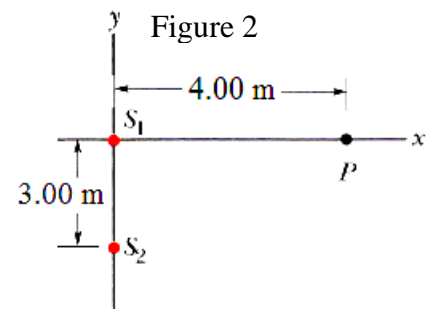
A point source emits sound wave with power  $3.14 \mu\text{W}$ . What is the sound level in decibels at a distance  $2.00 \text{ m}$  away?

- A) 48.0 dB
- B) 34.5 dB
- C) 21.5 dB
- D) 56.2 dB
- E) 40.0 dB

Q8.

Figure 2 shows two identical point sources  $S_1$  and  $S_2$  that emit sound waves, in phase, of frequency  $660\text{Hz}$  and speed of  $330 \text{ m/s}$ . What is the phase difference of the waves at the point  $P$ ?

- A)  $4 \pi$  rad.
- B)  $2 \pi$  rad.
- C)  $\pi$  rad.
- D)  $\pi/2$  rad.
- E)  $\pi/4$  rad.



Q9.

A steel tank is completely filled to the top with  $2.80 \text{ m}^3$  of ethanol when both the tank and the ethanol are at a temperature of  $32.0 \text{ }^\circ\text{C}$ . Now, the tank and its contents have been cooled to  $18.0 \text{ }^\circ\text{C}$ . Calculate the additional volume of ethanol that can be added to fill the tank to the top. [For the steel  $\beta = 3.60 \times 10^{-5} \text{ C}^{-1}$ , for the ethanol  $\beta = 7.50 \times 10^{-4} \text{ C}^{-1}$ ]

- A) 28.0 L
- B) 15.0 L
- C) 34.0 L
- D) 20.0 L
- E) 17.0 L

Q10.

One end of an insulated metal rod is maintained at  $100.0\text{ }^{\circ}\text{C}$  and the other end is maintained at  $0\text{ }^{\circ}\text{C}$  by an ice-water mixture. The rod is  $60.0\text{ cm}$  long and has a cross-sectional area of  $1.25\text{ cm}^2$ . The heat conducted by the rod melts  $8.50\text{ g}$  of ice in  $10.0\text{ min}$ . Find the thermal conductivity of the metal.

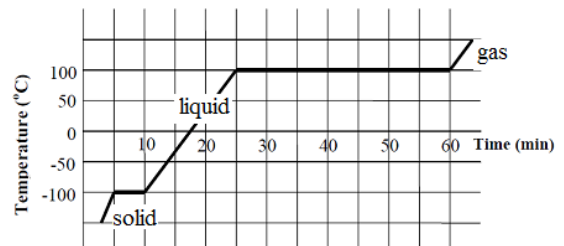
- A)  $226\text{ W/m.K}$
- B)  $362\text{ W/m.K}$
- C)  $103\text{ W/m.K}$
- D)  $412\text{ W/m.K}$
- E)  $160\text{ W/m.K}$

Q11.

When  $200\text{ W}$  is supplied continuously to an isolated object of mass  $0.400\text{ kg}$ , its phase changes from solid to liquid, and finally to gas as shown in **Figure 3**. What is the latent heat of vaporization, in  $\frac{\text{J}}{\text{kg}}$ , of the object?

- A)  $1.05 \times 10^6$
- B)  $2.00 \times 10^6$
- C)  $1.52 \times 10^7$
- D)  $2.35 \times 10^6$
- E)  $5.50 \times 10^6$

Figure 3



Q12.

Which of the following statements is **true**?

- A)  $dQ - dW$  represents the change in the internal energy of the system.
- B) In any cyclic process, the work done by the gas is zero.
- C) In an adiabatic process  $Q = W$ .
- D) At constant volume process the work done by the gas is positive.
- E) For the ideal gas  $C_p - C_v = R/2$ .

Q13.

The lowest pressure attainable in the laboratory is  $5.0 \times 10^{-18}$  Pa at  $20^\circ\text{C}$ . How many gas molecules are there per  $\text{m}^3$  at this pressure?

- A)  $1.2 \times 10^3$
- B)  $2.3 \times 10^3$
- C)  $4.4 \times 10^6$
- D)  $3.1 \times 10^5$
- E)  $5.6 \times 10^{-3}$

Q14.

At  $300\text{ K}$ , two moles of an ideal diatomic gas are contained in a cylinder, with a movable piston, of volume  $6.0\text{ L}$ . An amount of  $5.2\text{ kJ}$  of heat is added to the gas at constant pressure. Calculate the change in the volume, in Liters, of the gas.

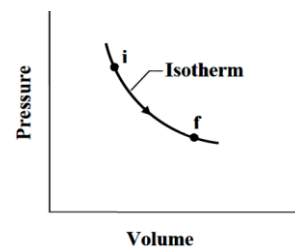
- A) 1.8
- B) 2.3
- C) 1.2
- D) 3.6
- E) 0

Q15.

One mole of an ideal gas expands isothermally from state **i** to state **f** as shown in **Figure 4**. At state **i** the volume of the gas is  $V_0$ , and the pressure is  $p_0$ . At state **f** the volume is  $3V_0$ . How much heat is added to the gas as it expands from state **i** to state **f**?

- A)  $p_0 V_0 \ln 3$
- B)  $2 p_0 V_0 \ln 3$
- C)  $p_0 V_0 \ln 2$
- D)  $2 p_0 V_0 \ln 2$
- E)  $(p_0 V_0 \ln 3)/4$

Figure 4



Q16.

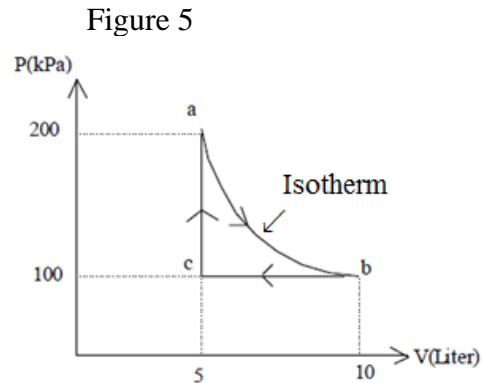
One liter of a gas, with  $\gamma = 1.30$ , initially at  $21.0^\circ\text{C}$  and  $1.00\text{ atm}$ , is compressed adiabatically to half of its initial volume. Find its final temperature.

- A) 362 K
- B) 500 K
- C) 25.9 K
- D) 300 K
- E) 120 K

Q17.

A constant amount of an ideal gas undergoes the cyclic process abca in the P-V diagram shown in **Figure 5**. The efficiency of the cycle is 20%. Find the heat added to the gas during the cycle.

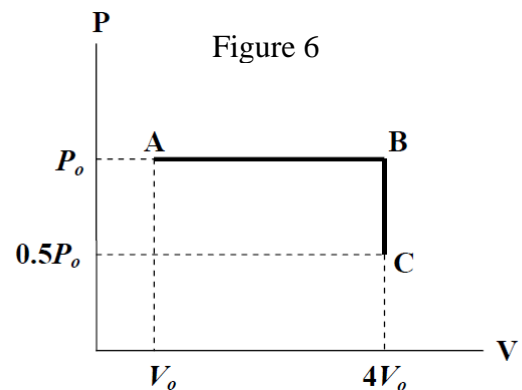
- A) 966 J
- B) 396 J
- C) 180 J
- D) 300 J
- E) 1298 J



Q18.

Two moles of a monatomic ideal gas are initially at the state A in the PV-diagram of **Figure 6**. The gas is heated and expands at constant pressure to the state B. It is then cooled at constant volume until the pressure has dropped to  $0.5P_0$  at the state C. Calculate the change in entropy of the gas in the ABC process.

- A)  $7R \ln(2)$
- B)  $5R \ln(2)$
- C)  $3R \ln(3)/2$
- D)  $7R \ln(3)$
- E)  $5R \ln(3)$



Q19.

A refrigerator, with a coefficient of performance of 4.0, expels 300 J of heat to the surrounding. How much heat is absorbed from inside the refrigerator?

- A) 240 J
  - B) 430 J
  - C) 120 J
  - D) 300 J
  - E) 400 J
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Q20.

Which one of the following statements is **true**?

- A) If the steam is condensed, its entropy will decrease.
  - B) The entropy of a system can never decrease.
  - C) For any closed system  $\Delta S < 0$ .
  - D) All the heat engines have efficiencies higher than Carnot's efficiency.
  - E) The total entropy of a system increases only if it absorbs heat.
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