Q1.

An 8.00 m long wire with a mass of 10.0 g is under a tension of 25.0 N. A transverse wave for which the wavelength is 0.100 m, and the amplitude is 3.70 mm is propagating on the wire. The magnitude of the maximum transverse acceleration of a point on the wire is:

A) 29.2×10^4 m/s^2
B) 41.0×10^4 m/s^2
C) 35.0×10^3 m/s^2
D) 39.0×10^3 m/s^2
E) 52.5×10^2 m/s^2

Ans:

$$a_{max} = \omega^2 y_m \Rightarrow \omega = 2\pi f = 2\pi \frac{v}{\lambda} = 8889 \text{ Hz}$$

$$v = \sqrt{\frac{\tau}{\mu}} = \sqrt{\frac{25}{\frac{10^{-2}}{8}}} = 141.42 \text{ m/s}$$

$$a_{max} = 29.2 \times 10^4 \text{ m/s}^2$$

Q2.

A sinusoidal transverse wave travels with a speed of 30.0 m/s on a string of length 8.00 m and mass 6.00 g. The average power of the wave is 50.0 W. What is the average power of the wave if the tension is increased such that the wave speed is doubled while keeping both the wavelength and the amplitude fixed.

A) 400 W
B) 300 W
C) 200 W
D) 600 W
E) 700 W

Ans:

$$P = \frac{1}{2} mv\omega^2 {y_m}^2 \propto v\omega^2$$

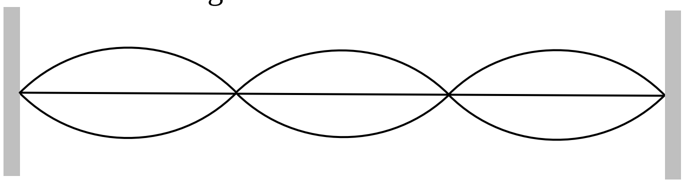
$$\left.\begin{matrix} P_1 \propto v_1 {\omega_1}^2 \\ P_2 \propto v_2 {\omega_2}^2 \end{matrix}\right\} \frac{P_2}{P_1} = \frac{v_2}{v_1} \times \left(\frac{\omega_2}{\omega_1}\right)^2 = \frac{2v_1}{v_1} \times \left(\frac{2\omega}{\omega_1}\right)^2$$

$$P_2 = 8P_1 = 400 \text{ W}$$

Q3.

Figure 1 shows a standing wave on a string under a fixed tension and oscillating at a frequency f. How many antinodes will there be if the frequency is doubled?

Figure # 1



A) 6
B) 8
C) 10
D) 4
E) 5

Ans:

A

Q4.

Two identical waves having a phase difference of 0.127 λ and moving in the same direction along a stretched string. They interfere with each other and the amplitude of the resultant wave is 14.0 mm. What is the amplitude of each wave?

A) 7.60 mm
B) 3.28 mm
C) 5.01 mm
D) 8.20 mm
E) 2.88 mm

Ans:

$$\phi = 0.127 = 2\pi \times 0.127\,\lambda = 45.72^{\circ}$$

$$y_m{}' = 2y_m \cos\left(\frac{\phi}{2}\right)$$

$$14.0 = 2y_m \times 0.921$$

$$y_m = \frac{14.0}{2 \times 0.921} = 7.60 \text{ mm}$$

Q5.

A standing sound wave in a pipe has five nodes and five antinodes. Find the harmonic number n for this standing wave.

A) 9
B) 8
C) 7
D) 12
E) 10

Ans:

A

Q6.

The pressure in a travelling sound wave is given by the equation
$\Delta p = (1.00\text{ Pa}) \sin \pi [(0.900\text{ m}^{-1})\,x - (315\text{ s}^{-1})t]$. Find the sound level of the wave (Take the density of air $\rho_{air} = 1.21\text{ kg/m}^3$).

A) 90.7 dB
B) 100 dB
C) 85.0 dB
D) 75.0 dB
E) 120 dB

Ans:

$$v = \frac{315}{0.9} = 350\text{ m/s}$$

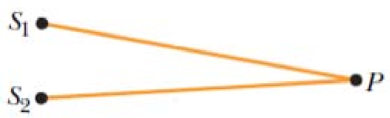
$$I = \frac{\Delta {p_m}^2}{2\rho v} = \frac{(1.00)^2}{2 \times 1.21 \times 350} = 1.1806 \times 10^{-3}\text{ w/m}^2$$

$$\beta = 10\log\left(\frac{1.1806 \times 10^{-3}}{10^{-12}}\right) = 90.7\text{ dB}$$

Q7.

Figure 2 shows two point sources S_1 and S_2, which are in phase and emit identical waves of wavelength λ. Initially, the sources are at equal distances from point P. Then S_1 is moved directly toward P by a distance equal to λ/4 and S_2 is moved directly away from P by a distance equal to λ/4. Now the waves at P:

Figure # 2



A) Are exactly out of phase.
B) Are exactly in phase.
C) Have some intermediate phase.
D) Have path difference equal to λ/4.
E) Have phase difference equal to π/4.

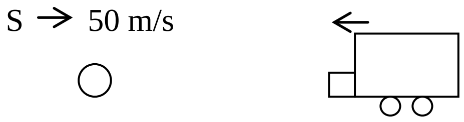
Ans:

A

Q8.

A sound source and a truck are approaching each other with speeds of 50.0 m/s and 30.0 m/s respectively. The source emits sound waves at a frequency of 0.150 MHz. Find the wavelength of the sound waves reflected back to the source.
(The speed of sound in air is 340 m/s)

A) 0.141 cm
B) 1.20 cm
C) 0.213 cm
D) 0.532 cm
E) 0.921 cm



Ans:

$$f' = f\left(\frac{v \pm v_d}{v \mp v_s}\right)$$

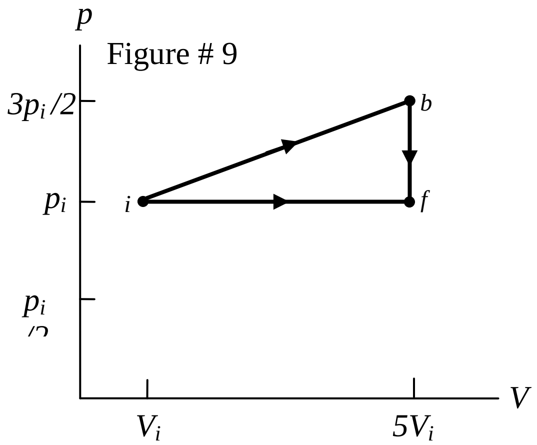
$$= (0.150\ \text{MHz})\left(\frac{340+30}{340-50}\right) = 0.191\ \text{MHz}$$

$$f'' = f'\left(\frac{340+50}{340-30}\right) = 0.240\ \text{MHz}$$

$$\lambda'' = \frac{v}{f''} = \frac{340}{0.240\times10^{6}} = 0.141\ \text{cm}$$

Q9.

A sample of a gas undergoes a transition from an initial state *i* to a final state *f* by two different paths, *if* and *ibf*, as shown in Figure 3. The energy transferred to the gas as heat along the path *if* is 10 p_iV_i. Find the change in internal energy of the gas for the path *ibf*.



A) 6 p_iV_i
B) p_iV_i
C) (3/2) p_iV_i
D) 10 p_iV_i
E) (5/2) p_iV_i

Ans:

$$(\Delta E_{int})_{if} = (\Delta E_{int})_{ibf}$$

$$Q_{if} - W_{if} = (\Delta E_{int})_{if}$$

$$10p_iV_i - p_1(4V_i) = (\Delta E_{int})_{if}$$

$$(\Delta E_{int})_{if} = (\Delta E_{int})_{ibf} = 6p_iV_i$$

Q10.

A cubic tank filled with 5.0 kg of water is insulated from all sides except its top which is covered with a square glass sheet of length 2.0 m and thickness 3.0 cm. The water is initially at 20 ^oC. It is exposed for 20 seconds to the outside environment where the temperature is 55 ^oC. Find the change in the temperature of water (assume that heat is distributed uniformly in the water).(K_{glass} = 1.0 W/m.K)

A) 4.5 ^oC
B) 2.5 ^oC
C) 0.6 ^oC
D) 1.5 ^oC
E) 8.5 ^oC

Ans:

$$Q = \frac{KA(T_H - T_L)t}{L} = m_\omega c_\omega \Delta T$$

$$\Delta T = \frac{KA(T_H - T_L)t}{m_\omega c_\omega L} = \frac{(1.0)(4)(55-20)(20)}{3 \times 10^{-2} \times 5.0 \times 4186}$$

$$\Rightarrow \Delta T = 4.5°C$$

Q11.

Water at 90.0 °C fills a Pyrex tube (radius=2.00 cm, height=12.0 cm) to the rim. If we ignore the expansion of the Pyrex tube, what will be the height of water if it is cooled to 10.0 °C. (The coefficient of volume expansion of water is 207×10^{-6} /C°)

A) 11.8 cm
B) 10. 4 cm
C) 10. 9 cm
D) 9.00 cm
E) 9.70 cm

Ans:

$\Delta v = Ah'$

$|\Delta v| = \beta V \Delta T$

$Ah' = 207 \times 10^{-6} \times (\cancel{A} \times .12)(+80)$

$h' = 0.198 \text{ cm}$

$\Delta h = h - h' = 11.8 \text{ cm}$

Q12.

Two different solid objects have the same mass and temperature. Equal quantities of energy are absorbed as heat by each. Their final temperatures may be different because the samples have different:

A) Specific heats
B) Coefficients of thermal expansion
C) Latent heat of fusion
D) volumes
E) thermal conductivities

Ans:

A

Q13.

An ideal gas initially at a pressure of 1.2 atm and temperature 74 ^{o}C undergoes an isothermal expansion to twice its original volume. During the expansion, the gas absorbs 20 kJ of heat. Find the number of moles for this gas?

A) 10
B) 12
C) 15
D) 18
E) 20

Ans:

$$\Delta E = 0 \Rightarrow Q = W = nRT\ln\left(\frac{v_f}{v_i}\right)$$

$$\Rightarrow n = \frac{Q}{RT\ln\left(\frac{v_f}{v_i}\right)} = 10 \text{ moles}$$

Q14.

An ideal gas with a volume V_0 and a pressure P_0 undergoes a free expansion to volume V_1 and pressure P_1 where $V_1=32V_0$. The gas is then compressed adiabatically to the original volume V_0 and pressure $4P_0$. The ratio of specific heats, γ, of the ideal gas is:

A) 7/5
B) 2/5
C) 3/5
D) 1/5
E) 9/5

Ans:

Free expansion: $P_1V_1 = P_0V_0 \;\; (V_1 = 32\,V_0)$

Adiabatic compression: $P_1V_1^{\,r} = 4P_0V_0^{\,r}$

$$\Longrightarrow \frac{P_0V_0}{32V_0}(32V_0)^r = 4P_0V_0^{\,r} \;\Rightarrow r = 1.4 = \frac{7}{5}$$

Q15.

The pressure of a monatomic ideal gas is doubled, while its volume is reduced by a factor of four. What is the ratio of the new rms speed of the atoms to the initial rms speed?

A) 0.71
B) 1.0
C) 0.47
D) 0.28
E) 0.87

Ans:

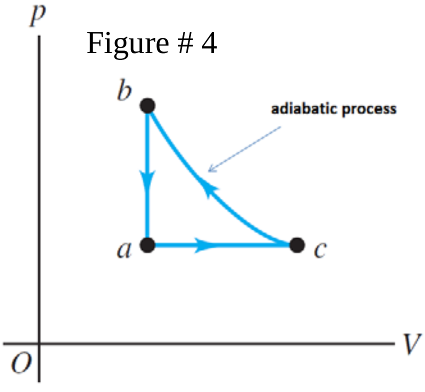
$$(v_{rms})_i = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3PV}{nM}}$$

$$(v_{rms})_f = \sqrt{\frac{3}{nM}(2P)\frac{V}{4}} = \frac{1}{\sqrt{2}}(v_{rms})_i \Rightarrow \frac{(v_{rms})_f}{(v_{rms})_i} = \frac{1}{\sqrt{2}}$$

Q16.

Three moles of an ideal diatomic gas are taken through the cycle *acba* as shown in Figure 4, where *cb* is an adiabatic process. The temperature of the gas in states a, c, and b are T_a = 300 K, T_c = 492 K, and T_b = 600 K respectively. Calculate the net work for the cycle.

A) −1.95 kJ
B) +1.95 kJ
C) +3.84 kJ
D) −3.84 kJ
E) 0



Ans:

$$\Delta E = 0 \Rightarrow W = Q$$

$$= Q_{ac} + Q_{cb} + Q_{ba}$$

$$= nC_p\Delta T + 0 + nC_v\Delta T$$

Q17.

An ideal refrigerator has a coefficient of performance of 5.0. If the temperature in the room is 31 °C, what is the temperature inside the refrigerator?

A) −20 °C
B) –5.0 °C
C) −10 °C
D) −30 °C
E) Zero

Ans:

$$k = 5 = \frac{T_L}{T_H - T_L} \Rightarrow \frac{1}{5} = \frac{T_H}{T_L} - 1$$

$$\frac{T_H}{T_L} = 1 + \frac{1}{5} \Rightarrow T_L = \frac{T_H}{1+\frac{1}{5}} = -20\ °C$$

Q18.

Consider an ideal engine that operates between two reservoirs at 300 K and 600 K and absorbs 1.44×10^6 J per cycle. What is the power output of this engine if it completes 10 cycles per minute?

A) 120 kW
B) 100 kW
C) 350 kW
D) 440 kW
E) 500 kW

Ans:

$$\frac{Q_H}{Q_L} = \frac{T_H}{T_L} = \frac{600}{300} = 2 \Rightarrow Q_L = \frac{1.44 \times 10^6}{7}\ \text{J per cycle}$$

$$W = 7.2 \times 10^5 \text{J per cycle}$$

$$\text{In one second } P = \frac{W}{t} = \frac{7.2 \times 10^5}{6} = 120\ \text{kW}$$

Q19.

An ideal monatomic gas of volume of 6.00 L, originally at 127 °C and a pressure of 3.00 atm undergoes an isothermal expansion to 4 times the original volume. What is the change in entropy of the gas for this process?

A) 6.3 J/K
B) 5.0 J/K
C) 3.4 J/K
D) 4.0 J/K
E) 7.1 J/K

Ans:

$$\Delta S = nR\ln\left(\frac{V_f}{V_i}\right)$$

$$= \frac{pV}{T}\ln 4 = \frac{3 \times 1.01 \times 10^5 \times 6 \times 10^{-3}}{400}\ln 4 = 6.3\ J/K$$

Q20.

A piece of iron of mass 2.00 kg at a temperature of 880 K is thrown into a large lake whose temperature is 280 K. Assume the lake is so large that its temperature change can be ignored. If the change in entropy of the **iron-lake system** is 898 J/K, calculate the specific heat of iron.

A) 450 J/kg K
B) 350 J/kg K
C) 230 J/kg K
D) 190 J/kg K
E) 580 J/kg K

Ans:

$$\Delta S = \Delta S_{iron} + \Delta S_{lake}$$

$$= mc_i \ln\left(\frac{T_f}{T_i}\right) + \frac{Q}{T_{lake}}$$

$$= mc_i \ln\left(\frac{T_f}{T_i}\right) + \frac{mc_i \Delta T}{T_{lake}} = 898\frac{J}{k}$$

solve for c