Q1.

Which of the following types of waves is NOT a transverse wave

A) Sound Waves
B) Radio Waves
C) Micro Waves
D) Visible light Waves
E) Waves in a stretched string

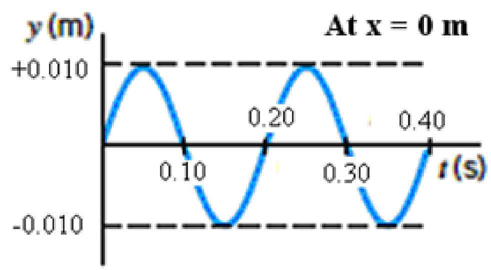
Ans:

A

Q2.

FIGURE 1 shows a graph that represents a transverse wave on a string. The wave is moving in the +x direction with a speed of 0.15 m/s. Using the information contained in the graph, write the expression for the wave

Figure 1



A) $y = 0.01\sin(209x - 31.4t)$
B) $y = 0.01\sin(209x + 31.4t)$
C) $y = 0.04\sin(209x - 6.28t)$
D) $y = 0.01\sin(0.942x - 31.4t)$
E) $y = 0.01\sin(0.942x + 31.4t)$

Ans:

$$T = 0.25;\ \omega = \frac{2\pi}{0.2} = 10\pi = 31.4$$

$$V = f\lambda \Rightarrow \lambda = \frac{V}{f} = \frac{V}{\omega/2\pi} = \frac{2\pi V}{\omega}$$

$$K = \frac{2\pi}{2\pi \frac{V}{\omega}} = \frac{2\pi\omega}{2\pi V} = \frac{\omega}{V}$$

$$K = \frac{10\pi}{0.15} = \frac{10\pi}{0.15} = \frac{200}{3}\pi = 209$$

Q3.

A string has linear density μ = 526 g/m and is under tension of 19.0 N. We send a sinusoidal wave given by equation $y = 0.025\sin(15.0\,x - 90.1\,t)$, where all numerical constants are in SI units. At what average rate does the wave transport energy?

A) 8.02 W
B) 2.33 W
C) 16.0 W
D) 5.20 W
E) 11.0 W

Ans:

$$P_{avg} = \frac{1}{2}\mu v (y_m \omega)^2$$

$$= \frac{1}{2} \times 526 \times 10^{-3} \times \frac{90.1}{15}(0.025 \times 90.1)^2 = 1.3343978 \times v = 8.01528 \text{ W}$$

Q4.

Two identical waves of amplitude y_m and wavelength λ moving in the same direction along a stretched string, interfere with each other. If the phase difference between them, expressed in wavelengths, is 0.35, find the amplitude of the resultant wave.

A) 0.91 y_m
B) 2.0 y_m
C) 0.43 y_m
D) 1.2 y_m
E) 0.35 y_m

Ans:

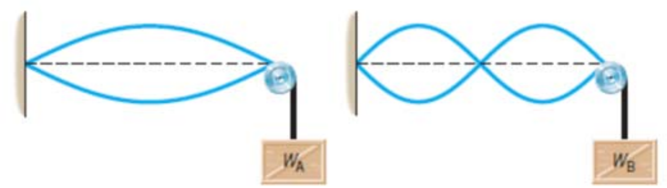
$$\lambda = 360° \Rightarrow 0.35\lambda = 0.35 \times 360 = 126°$$

$$y = 2y_m cos\left(\frac{126}{2}\right) = 0.9079\, y_m$$

Q5.

FIGURE 2 shows two strings that have the same length and same linear density. The left end of each string is attached to a wall, while the other connected to blocks of different weights, W_A and W_B. Different standing waves are set up on each string, as shown, but their frequencies are the same. If W_A= 44 N, what is W_B?

Figure 2



A) 11 N
B) 22 N
C) 33 N
D) 44 N
E) 25 N

Ans:

$$f_{1A} = \frac{1 \cdot V_A}{2L};\ f_{2B} = \frac{2 \cdot V_B}{2L}$$

$$f_{1A} = f_{2B}$$

$$\frac{V_A}{2L} = \frac{2V_B}{2L}$$

$$\sqrt{\frac{W_A}{\mu}} = 2\sqrt{\frac{W_B}{\mu}}$$

$$W_A = 4W_B \Rightarrow 44 = 4W_B$$

$$W_B = 11\ \text{N}$$

Q6.

The maximum pressure amplitude Δp_m that the human ear can tolerate in loud sound is about 28.0 Pa. What is the displacement amplitude s_m for such a sound in air of density 1.21 kg/m^3, at frequency of 5000 Hz and a speed of 343 m/s?

A) 2.15 µm
B) 7.21 µm
C) 4.62 µm
D) 1.59 µm
E) 3.53 µm

Ans:

$$\Delta p_m = \rho V \omega S_m$$

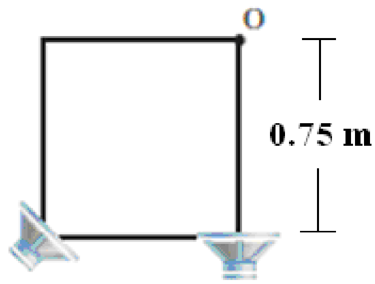
$$28 = 1.21 \times 343 \times 2\pi(5000) S_m$$

$$S_m = \frac{28}{13038551.99} = 2.1474 \times 10^{-6}\ \text{m}$$

Q7.

FIGURE 3 shows a square with side lengths of 0.75 m and an observer O is at one corner of the square. The speakers produce sound waves that are in phase and of identical wavelength. Find the smallest frequency that will produce constructive interference at O.

Figure 3



A) 1.1×10^3 Hz
B) 5.5×10^2 Hz
C) 3.2×10^2 Hz
D) 8.4×10^2 Hz
E) 6.8×10^3 Hz

Ans:

$$\Delta L = |OS_1| - |OS_2|$$

$$\Delta L = \lambda$$

$$\lambda = \sqrt{2(0.75)^2} - 0.75 = \sqrt{(2-1)} - 0.75 = \frac{3\sqrt{2}-3}{4}$$

$$V = f\lambda$$

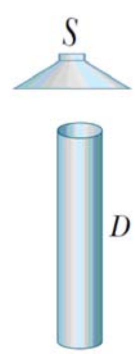
$$343 = f\frac{3\sqrt{2}-3}{4} = 1104.100 \text{ Hz}$$

$$f = 1104.100 \text{ Hz}$$

Q8.

In **FIGURE 4**, *S* is a small speaker driven by an audio oscillator with a frequency that is varied from 1000 Hz to 2000 Hz, and *D* is a cylindrical pipe with two open ends and a length of *L*= 45.1 cm. At how many frequencies does the sound from the speaker set up resonance in the pipe?

Figure 4



A) 3
B) 1
C) 2
D) 4
E) 5

Ans:

$$f_1 = \frac{v}{2L} = \frac{343}{2\times45.1\times10^{-2}}$$

$$f_1 = 381 \text{ Hz};\ f_2 = 762 \text{ Hz}$$

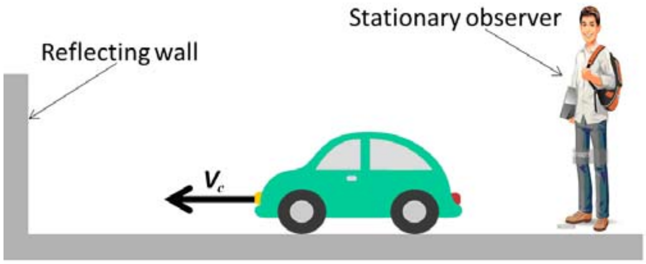
$$f_3 = 1143 \text{ Hz};\ f_4 = 1524.4 \text{ Hz}$$

$$f_5 = 1905 \text{ Hz}$$

Q9.

A car is approaching a reflecting wall with speed V_c. A stationary observer behind the car hears a sound of frequency 828 Hz directly from the car horn and a sound of frequency 971 Hz reflected from the wall, as shown in the **FIGURE 5**. Find the speed V_c of the car.

Figure 5



A) 27.3 m/s
B) 40.2 m/s
C) 12.5 m/s
D) 49.0 m/s
E) 32.3 m/s

Ans:

$$828 = f = \frac{343 - 0}{343 + V}$$

$$971 = f = \frac{343}{343 - V}$$

$$\frac{828}{971} = \frac{\frac{343}{343 + V}}{\frac{343}{343 - V}} = \frac{343 - V}{343 + V}$$

$$828(343 + V) = 971(343 - V)$$

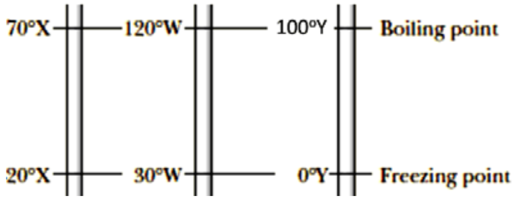
$$828V + 971\,V = 971 \times 343 - 828 \times 343$$

$$1799V = 143 \times 343 \Rightarrow V = 27.264\ \mathrm{m/s}$$

Q10.

FIGURE 6 shows three linear temperature scales with freezing and boiling points of water indicated. Rank the temperatures; 50^o X, 50^o W, and 50^o Y, GREATEST FIRST.

Figure 6



A) 50^o X, 50^o Y, and 50^o W
B) 50^o X, 50^o W, and 50^o Y
C) 50^o Y, 50^o W, and 50^o X
D) 50^o Y, 50^o X, and 50^o W
E) 50^o W, 50^o X, and 50^o Y

Ans:

A

Q11.

One rod is made from lead and another from quartz. The rods are heated and experience the same change in temperature. The change in length of each rod is the same. If the initial length of the lead rod is 0.10 m, what is the initial length of the quartz rod? ($\alpha_{lead} = 29 \times 10^{-6}$ /°C, $\alpha_{Quartz} = 0.50 \times 10^{-6}$ /°C)

A) 5.8 m
B) 7.2 m
C) 2.9 m
D) 9.2 m
E) 3.8 m

Ans:

$$\Delta L_L = \Delta L_\theta$$

$$L_{OL}\alpha_L \Delta T = L_{OQ}\alpha_Q \Delta T$$

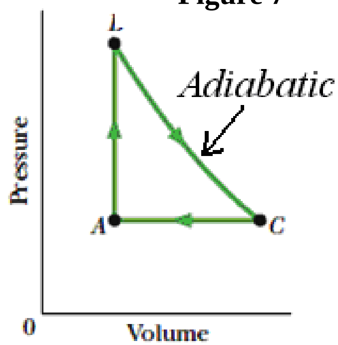
$$0.1 \times 29 \times 10^{-6} = L_{OQ} \cdot 0.5 \times 10^{-6}$$

$$L_{OQ} = 5.8 \text{ m}$$

Q12.

Gas held within a chamber passes through the cycle shown in **FIGURE 7**, where AB and AC are along the vertical and the horizontal directions, respectively. The net work done during the cycle is 20 J and heat added during process AB is 25 J. Find the energy transferred as heat Q during the process CA.

Figure 7



A) − 5.0 J
B) + 5.0 J
C) + 45 J
D) − 45 J
E) + 20 J

Ans:

$$\Delta E_{int-cyc} = 0$$

$$\therefore Q_{cyc} - W_{cyc} = 0$$

$$Q_{cyc} = W_{cyc}$$

$$Q_{AB} + Q_{BC} + Q_{CA} = 20$$

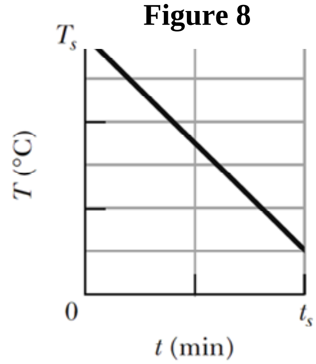
$$25 + 0 + Q_{CA} = 20$$

$$Q_{CA} = 20 - 25 = -5 \text{ J}$$

Q13.

A 0.300 kg sample is placed in a cooling apparatus that removes energy as heat at a constant rate of 2.81 W. **FIGURE 8** gives the temperature *T* of the sample versus time *t*. The temperature scale is set by T_s =30.0°C and the time scale is set by t_s =20.0 min. What is the specific heat of the sample?

Figure 8



A) 450 J/Kg.K
B) 936 J/Kg.K
C) 140 J/Kg.K
D) 281 J/Kg.K
E) 523 J/Kg.K

Ans:

$$P \times \Delta t = mc\Delta T$$

$$P = mc\frac{\Delta T}{\Delta t}$$

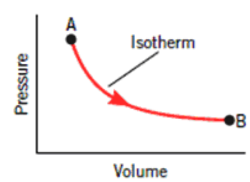
$$2.81 = 0.3 \times C \cdot \frac{25}{20 \times 60} = \frac{1}{160} \times C$$

$$C = 449.6 = 450 \text{ J/Kg.K}$$

Q14.

An Ideal monoatomic gas expands isothermally from A to B, as shown in **FIGURE 9**. What can be said about the process?

Figure 9



A) There is no change in the internal energy of the gas
B) The gas does no work
C) No heat is gained or lost by the gas
D) The first law of thermodynamics does not aply to an isothermal process
E) The ideal gas law is not valid during isothermal process

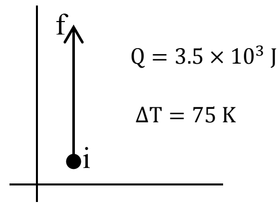
Ans:

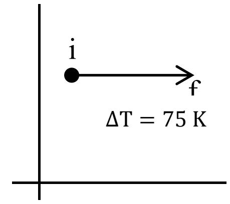
A

Q15.

Under constant volume conditions, 3.50×10^3 J of heat is added to 1.60 moles of an ideal gas. As a result, the temperature of the gas increases by 75.0 K. How much heat would be required to cause the same temperature change under constant pressure conditions?

A) 4.50×10^3 J
B) 2.50×10^3 J
C) 3.50×10^3 J
D) 7.34×10^3 J
E) 9.45×10^3 J





Ans:

$$\Delta E_{int} = Q_1 - W_1$$

$$\Delta E_{int} = Q_1 - 0$$

$$\Delta E_{int} = 3.5 \times 10^3 J$$

$$\Delta E_{int} = Q_2 - W_2$$

$$3.5 \times 10^3 = Q_2 - nR\Delta T$$

$$Q_2 = 3.5 \times 10^3 + 1.6 \times 8.31 \times 75 = 4497.5 = 4.498 \times 10^3 J$$

Q16.

Five moles of an ideal monatomic gas with an initial temperature of 127°C expand and, in the process, absorb 1200 J of heat and do 2100 J of work. What is the final temperature of the gas?

A) 113 °C
B) 214 °C
C) 322 °C
D) 521 °C
E) 436 °C

Ans:

$$\Delta E_{int} = Q - W$$

$$\frac{3}{2} nR(\Delta T) = 1200 - 2100$$

$$\frac{3}{2} \times 5 \times 8.31(T_f - T_i) = -900$$

$$T_f - 127 = -14.44$$

$$T_f = 112.56 = 113°C$$

Q17.

0.500 mole of a monatomic ideal gas expands adiabatically and does 610 J of work. By how many kelvins does the temperature change?

A) −97.9 K
B) −147 K
C) +147 K
D) –73.4 K
E) −120 K

Ans:

$Q = 0$

$\Delta E_{int} = nC_v\Delta T$

$\Delta E_{int} = -W$

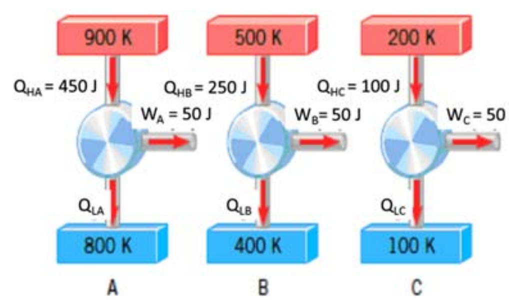
$$-610 = 0.5 \times \frac{3}{2} \times 8.31 \cdot \Delta T$$

$\Delta T = 97.87$ K

Q18.

Three Carnot engines A, B, and C as shown in **FIGURE 10** operate with hot and cold reservoirs whose temperature differences are 100 K. Rank the change in entropy S of the cold reservoirs, GREATEST FIRST.

Figure 10



A) All tie
B) S_A, S_B, S_C
C) S_C, S_A, S_B
D) S_A, S_C, S_B
E) S_B, S_A, S_C

Ans:

$$\Delta S = \frac{Q}{T}$$

$Q_{LA} = 400$ J ; $Q_{LB} = 200$ J ; $Q_{LC} = 50$ J

$$\Delta S_A = \frac{400}{800} = \frac{1}{2}$$

$$\Delta S_B = \frac{200}{400} = \frac{1}{2}$$

$$\Delta S_C = \frac{50}{100} = \frac{1}{2}$$

Q19.

A Carnot engine operates with a large hot reservoir and a much smaller cold reservoir. As a result, the temperature of the hot reservoir remains constant while the temperature of the cold reservoir slowly increases. This temperature change decreases the efficiency of the engine to 0.70 from 0.75. Find the ratio of the final temperature of the cold reservoir to its initial temperature (T_{Lf}/T_{Li}).

A) 6/5
B) 1
C) 15/14
D) 9/7
E) 13/12

Ans:

$$\varepsilon_{c1} = 1 - \frac{T_{Li}}{T_{Hi}}$$

$$0.75 = 1 - \frac{T_{Li}}{T_H} \Rightarrow \frac{T_{Li}}{T_H} = 0.25$$

$$0.70 = 1 - \frac{T_{LF}}{T_H} \Rightarrow \frac{T_{LF}}{T_H} = 0.30$$

$$\frac{\frac{T_{LF}}{T_H}}{\frac{T_{Li}}{T_H}} = \frac{0.3}{0.25} \Rightarrow \frac{\frac{T_{LF}}{T_H}}{\frac{T_{Li}}{T_H}} = \frac{T_{LF}}{T_{Li}} = \frac{6}{5}$$

Q20.

A Carnot engine has an efficiency of 0.55. If this engine were run backward as a heat pump, what would be the coefficient of performance?

A) 0.82
B) 1.0
C) 1.2
D) 0.45
E) 0.55

Ans:

$$\varepsilon_i = 0.55 = \frac{W}{Q_H} = 1 - \frac{Q_L}{Q_H}$$

$$W = 0.55\ Q_H; \frac{Q_L}{Q_H} = 1 - 0.55 = 0.45$$

$$K_C = \frac{Q_L}{\omega} = \frac{Q_L}{Q_H - Q_L} = \frac{0.45\ Q_H}{Q_H - 0.45\ Q_H} = \frac{0.45}{1 - 0.45} = 0.81818$$
