Q1.

A stretched string has a length of 2.00 m and a mass of 3.40 g. A transverse sinusoidal wave is travelling on this string, and is given by: y (x, t) = 0.030 sin (0.75 x – 126 t), where x and y are in meters, and t is in seconds. What is the magnitude of the tension in this string?

A) 48 N
B) 56 N
C) 43 N
D) 35 N
E) 64 N

Ans:

$$v = \sqrt{\frac{\tau}{\mu}} \Rightarrow \tau = v^2\mu = \frac{\omega^2}{K^2}\,\mu = \frac{126^2}{0.75^2}\frac{3.4\times10^{-3}}{2} = 48\ N$$

Q2.

A wave in a string, is given by the equation:

y(t) = 0.24 sin (3.0 x – 24t).

Where *x* and *y* are in meters and t is in seconds. Calculate the value of the transverse speed at *x* = 2.0 m and *t* = 1.0 s.

A) 3.8 m/s
B) 5.5 m/s
C) 1.2 m/s
D) 2.1 m/s
E) 8.0 m/s

Ans:

$$y\,(x,t) = 0.24\sin(3x - 24\,t)$$

$$v\,(x,t) = \frac{dy}{dt}\,(t) = -24\times0.24\,cos\,(3x - 24t)$$

$$v\,(2,1) = -24\times0.24\cos(6 - 24) = 3.8$$

Q3.

A stretched string has a mass per unit length of 0.50 kg/m. A sinusoidal wave of frequency 1.0 Hz travelling on this string has an amplitude of 5.2 cm. If 0.25 J of energy is transported through the string during the time $t = 50T$ (T = time period for one oscillation), the wavelength of the wave is:

A) 19 cm
B) 25 cm
C) 37 cm
D) 45 cm
E) 59 cm

Ans:

$$P_{ar} = \frac{1}{2}\mu v\omega^2 y_m^2$$

$$\frac{0.25}{50\,T} = \frac{1}{2} \times 0.5\lambda f \cdot 4\pi f^2 y_m^2$$

$$\Rightarrow \lambda = \frac{0.25 \times 2}{50 \times 0.5 \times 4 \times 3.14 \times 5.2 \times 10^{-2}} = 19\ cm$$

Q4.

Two waves travelling along the same string are described by the wave equations (in SI units)

$y_1(t) = 3.0\sin(4x - 1.4t)$, and $y_2(t) = 3.0\sin(4x - 1.4t + \pi/2)$

Find the amplitude of the resultant wave.

A) 4.2 m
B) 1.3 m
C) 6.8 m
D) 2.5 m
E) 3.2 m

Ans:

$$y_1(t) = 3\sin(4 \times -1.4\,t), \quad y_2 = 3\sin\left\{(4x - 1.4\,t) + \frac{\pi}{2}\right\}$$

$$\mathcal{C} = \frac{\pi}{2}$$

$$y_{m,R} = 2y_m cos\left(\frac{\mathcal{C}}{2}\right) = 2 \times 3\cos(45°) = 4.2\ m$$

Q5.

Two sound waves, from two different sources with the same frequency, 540 Hz, travel in air in the same direction. The sources are in phase. What is the phase difference of the waves at a point that is 4.40 m from one source and 4.00 m from the other?

A) 227°
B) 158°
C) 340°
D) 401°
E) 635°

Q6.

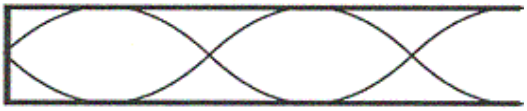
The sound level at a distance of 3.0 m from a point source is 120 dB. At what distance is the sound level 100 dB?

A) 30 m
B) 9.0 m
C) 65 m
D) 6.0 m
E) 12 m

Q7.

A pipe of length 0.500 m filled with air is closed at one end and open at the other. What is the resonant frequency corresponding to the mode shown in **Figure 1**?

Fig#



A) 857 Hz
B) 170 Hz
C) 403 Hz
D) 349 Hz
E) 512 Hz

Q8.

In **Figure 2**, submarine A and submarine B move toward each other in motionless water in the Atlantic Ocean. Submarine A moves at speed v_A = 50.0 km/h, and the submarine B at v_B = 70.0 km/h. Submarine A sends out a sonar signal (sound wave in water) at 1.00×10^3 Hz. Sonar waves travel at 5470 km/h. What is the signal's frequency as detected by submarine B?

Fig#

A) 1.02 kHz

B) 2.16 kHz
C) 4.02 kHz
D) 3.34 kHz
E) 5.22 kHz

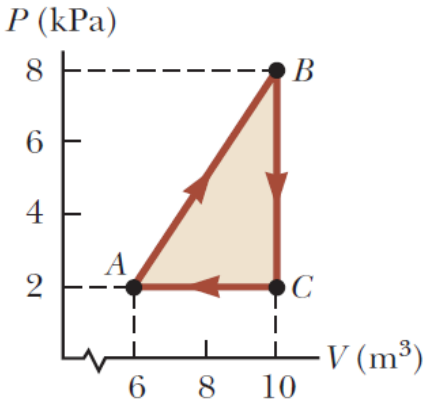
Q9.
A metal rod has a length of 7.3 m at 15 °C and a length of 7.4 m at 95 °C. What is the temperature of the rod when its length is 7.2 m?

A) −66 °C
B) +66 °C
C) +24 °C
D) −24 °C
E) +78 °C

Q10.
Materials A, B, and C are solids that are at their respective melting temperatures. 4 kg of material A requires 200 J of heat energy to melt, 5 kg of material B requires 300 J of heat energy to melt, and 6 kg of material C requires 300 J of heat energy to melt. Rank the materials according to their heats of fusion (L_F), **greatest first**.

A) B, then A and C tie
B) A, then B and C tie
C) C, then B and A tie
D) B , then C, then A
E) C, then A, then B

Q11.
A gas is taken through the cyclic process described in the **Figure 3**. The net heat energy transferred to the system and the net work done by the system, during one complete cycle are, respectively.
Fig#



A) +12 kJ and +12 kJ
B) −12 kJ and +12 kJ
C) +12 kJ and zero
D) zero and −12 kJ
E) −12 kJ and −12 kJ

Q12.
Star A has twice the radius and twice the absolute surface temperature of star B. The emissivity of both stars can be assumed to be 1. What is the ratio of the power radiated by star A to that of star B? (Assume that the stars are perfectly spherical in shape)

A) 64
B) 8
C) 16
D) 4
E) 32

Q13.
A 5.00 mole of ideal gas is in a container at 27.0 ^{o}C and its root mean square (rms) speed is 517 m/s. Find the total mass of the gas.

A) 140 g
B) 210 g
C) 354 g
D) 427 g
E) 535 g

Q14.
An ideal gas undergoes an adiabatic compression from $P_0 = 1.0$ atm, $V_0 = 1.0 \times 10^6$ L to $P = 6.0 \times 10^3$ atm, $V = 2.0 \times 10^3$ L. Which of the following could be the gas? (Values of γ for monoatomic gases = 1.66, for diatomic gases = 1.4, and for polyatomic gases = 1.33.)
A) Nitrogen (N_2)
B) Helium (He)
C) Ammonia (NH_3)
D) Water vapor (H_2O)
E) Methene (CH_4)

Q15.
600 kJ of heat energy is supplied to an ideal monoatomic gas which undergoes an isobaric expansion. The change in its internal energy during this process is:

A) 360 kJ
B) 120 kJ
C) 240 kJ
D) 480 kJ
E) 720 kJ

Q16.
The internal energy of a fixed mass of an ideal gas depends on:

A) temperature, but not on volume or pressure.
B) pressure, but not on volume or temperature.
C) volume, but not on temperature or pressure.
D) temperature and pressure, but not on volume
E) temperature and volume, but not on pressure.

Q17.
An ideal gas undergoes a reversible isothermal expansion at 130 °C. The entropy of the gas increases by 46.0 J/K. What is the work done in this process?

A) 1.85×10^4 J
B) 5.98×10^3 J
C) 3.54×10^3 J
D) 2.83×10^4 J
E) 8.70×10^3 J

Q18.
A 200 g ice ball at 0 °C is dropped into a large fresh water lake at 20 °C. Which one of the following statements is **False**?

A) The change in entropy of the lake cannot be calculated because its mass is unknown.
B) The change in entropy of the ice ball is positive.
C) The change in entropy of the lake is negative.
D) The magnitude of change in entropy of the ice ball is greater than that of the lake.
E) The ice ball melts and eventually becomes water at 20°C.

Q19.
A 35.0% efficient Carnot heat engine is run in reverse so as to form a Carnot refrigerator. What would be this refrigerator's coefficient of performance?
A) 1.86
B) 3.65
C) 2.86
D) 5.35
E) 4.95

Q20.
A refrigerator, having a power output of 300 W, has a coefficient of performance 3.0. How many minutes does it take to convert 3.0 kg of water at 27 °C into ice at 0 °C?

A) 25
B) 15
C) 35
D) 45
E) 55
