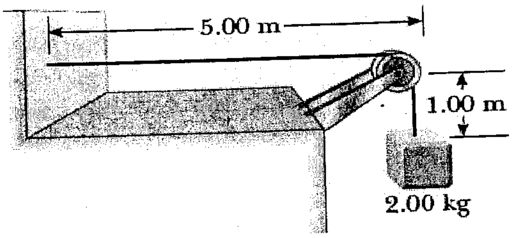
3. In the arrangement shown in figure, an object (mass = 2 kg) is hung from a string that passes over a light pulley. The another end of string is tied to a wall . If mass of string is 0.3 kg and length 6 m. Find the speed of the wave on this string. مذكرة

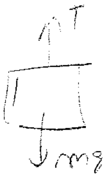


(A) 0.05 m/s
(B) 18.07 m/s
✓ (C) ~~19.6 m/s~~ 19.8 m/s
(D) ~~20.8 m/s~~ 22.8 m/s

$v = \sqrt{\frac{T}{\mu}}$

$= \sqrt{\frac{19.6}{0.05}}$

$= 19.8$ m/s



$T - mg = 0$

$T = mg$

$= (2)(9.8) = 19.6$ N

$\mu = \frac{m}{L} = \frac{0.3}{6} = 0.05$

✓ 4. A wave traveling along string is described by

y(x,t) = 0.00327 sin(72.1x-2.72t),

in which the numerical constants are in SI units (0.00327 m, 72.1 rad/m, and 2.72 rad/s). What is the displacement y at x = 22.5 cm and t=18.9 s?

(A) 0.92 mm
(B) 1.75 mm
✓ (C) 1.92 mm
(D) 2.98 mm

$y = 0.00327 \sin((72.1)(0.225) - (2.72)(18.9))$

$= 1.92$ mm

---

1. A 2.00 kg object attached to a spring moves without friction and is driven by an external force given by $F = 6\overset{\cos}{\cancel{\sin}}(2\pi t)$. If the force constant of the spring is 18 N/m, determine the amplitude of the motion?

(A) 0.049 m

✓ ~~(B) 0.058 m~~ [illegible]

(C) 0.675 m

~~(D) 0.842 m~~ ~~(D) 0.098~~

$\omega_0 = \sqrt{\frac{k}{m}} = \sqrt{\frac{18}{2}} = 3$

$$A = \frac{F_0/m}{\sqrt{(\omega^2-\omega_0^2)^2+\left(\frac{\cancel{b}\omega}{m}\right)^2}} = \frac{F_0/m}{\omega^2-\omega_0^2} = \frac{6/2}{(2\pi)^2-3^2} = \frac{3}{30.48}$$

$= 0.098$ m

damping coefficient.

$b \to \gamma$

---

2. A pendulum has a period of 2.0 s on earth. What is its length?

✓(A) 1.0 m

(B) 2.0 m

(C) 6.26 m

(D) 39.2 m

$$T = 2\pi\sqrt{\frac{l}{g}} \qquad \omega = \sqrt{\frac{g}{l}}$$

$$\frac{T^2}{4\pi^2} g = l$$

$$l = \frac{(2)^{\cancel{2}}}{\cancel{4}\pi^2} 9.8 = 0.99 \text{ m}$$

1. SHM
2. Damped
3. ~~[illegible]~~ Standing

---

8 [illegible]

15

20 [illegible]

[illegible] 5 [illegible]

5. Residents of Hawaii are warned of the approach of a tsunami (tidal wave) by sirens mounted on the top of towers. Suppose a siren produces a sound that has an intensity level of 120 dB at a distance of 2.0 m. Treating the siren as a point source of sound, and ignoring reflections and absorption, find the intensity level heard by an observer at a distance of 12 m from the siren.

(A) 10.5 dB
(B) 52 dB
(C) 118.5 dB
(D) ~~104 dB~~ 104.4 dB

$\beta = 10\log\left(\frac{I}{I_0}\right)$

$120 = 10\log\left(\frac{I}{I_0}\right)$

$\frac{I_c}{I_0} = 10^{12}$

$I = 1\ W/m^2 = \frac{P}{4\pi(2)^2}$

$P = 16\pi\ W$

$I' = \frac{\cancel{16\pi}\,4}{\cancel{4\pi}(12)^2} = 0.0277$

$I' = 104.4\ dB$

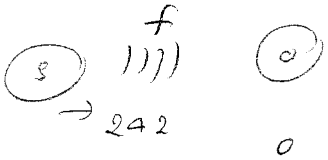
---

* 6. A rocket moves at a speed of 242 m/s directly toward a stationary pole (through stationary air) (with a temperature of 20°C) while emitting sound waves at frequency f = 1250 Hz. What frequency f′ is measured by a detector that is attached to the pole? ~~Sound velocity of sound = 343 m/s~~

(A) 3245 Hz
(B) 4245 Hz
(C) 5245 Hz
(D) 6245 Hz

The temperature of air is 20°C

$v = 330 + 0.6(T)$



$f' = f\left(\frac{v\ \overset{0}{\cancel{v_o}}}{v - v_s}\right) = 1250\left(\frac{343}{343 - 242}\right)$

$= 4245\ Hz$

---

7. What is the standing wave that result from the sum of two transverse traveling waves given by (Doppler) Notice that

y_1=2.0sin (πx-4πt), $= \mathrm{Im}(Y_1)$ where $Y_1 = 2e^{i(\pi x - 4\pi t)}$ (use Phasors) Euler formula

and y_2=2.0sin (πx+4πt) $Y_2 = 2e^{i(\pi x + 4\pi t)}$

where x, y_1,y_2 are in meters and t is in seconds $\therefore \Sigma y = \mathrm{Im}(Y_1 + Y_2)$

(A) 1.0sin (πx)cos(4πt)

(B) 2.0sin (πx)cos(4πt)

(C) 4.0cos (πx)sin(4πt)

(D) 4.0sin (πx)cos(4πt) ✓

$$Y_1 + Y_2 = 2e^{i\pi x}\left(e^{-i4\pi t} + e^{i4\pi t}\right)$$

$$= 4e^{i\pi x}\cos(4\pi t)$$

$$y_1 + y_2 = 2\sin(\pi x - 4\pi t) + 2\sin(\pi x + 4\pi t)$$

$$= 2\left(\sin\pi x\cos 4\pi t - \cancel{\cos\pi x\sin 4\pi t} + \sin\pi x\cos 4\pi t + \cancel{\cos\pi x\sin 4\pi t}\right)$$

this method requires knowledge of trigonometric identities.

$$y_1 + y_2 = y = 4\sin\pi x\cos 4\pi t$$

$$\therefore \Sigma y = 4\sin(\pi x)\cos(4\pi F)$$

---

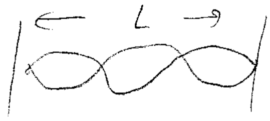
8. A string, fixed at both ends vibrates at a frequency of 12 Hz with a standing transverse wave pattern containing 3 loops. What frequency is needed if the standing wave pattern is to contain 4 loops?

(A) 48 Hz

(B) 36 Hz

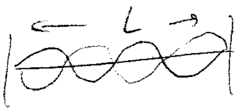
(C) 16 Hz ✓

(D) 12 Hz



$L = \frac{3\lambda}{2}$; $\lambda = \frac{2}{3}L$

$v = f\lambda = (12)\left(\frac{2}{3}\right)L$ —①



$L = \frac{4\lambda'}{2}$

$L = 2\lambda$; $\lambda' = \frac{L}{2}$

$v = f'\left(\frac{L}{2}\right)$ —②

① = ②

$12\left(\frac{2}{3}\right)\cancel{L} = f'\left(\frac{\cancel{L}}{2}\right)$

$f' = 12\left(\frac{4}{3}\right) = \frac{48}{3} = 16$ Hz

9. Consider a wave function

$$y(x,t) = 6.5\text{mm}\sin 2\pi\left(\frac{x}{28.0\text{cm}} - \frac{t}{0.036\text{s}}\right).$$

Please find amplitude, wavelength, frequency and velocity, respectively.

- ✓(A) 0.0065 m, 0.28 m, 27.78 Hz, 7.78 m/s
- (B) 0.0065 m, 0.036 m, 27.78 Hz, 1.0 m/s
- (C) 6.5 m, 28 m, 0.036 Hz, 1.0 m/s
- (D) 6.5 m, 28 m, 36 Hz, 1.0 m/s

$$y = A \sin 2\pi\left(\frac{x}{\lambda} - \frac{t}{T}\right)$$

---

10. A building made with a steel structure is 650 m high on a winter day when the temperature is -17.78° C. How much taller (in cm) is the building when it is 37.78° C? (The linear expansion coefficient of steel is 11×10^{-6} $(°C)^{-1}$.)

- (A) 71
- (B) 36
- ✓(C) 40
- (D) 46

$$\Delta L = \alpha L_i \Delta T = (11\times10^{-6})(650)(37.78+17.78)$$

$$= 0.399 \text{ m}$$

$$\simeq 40 \text{ cm}$$

11. Two bodies can be in thermal equilibrium with one another when they are at the same temperature even if they

(A) absorb different quantities of thermal energy from their surroundings in equal time intervals.

(B) have different masses.

(C) have different volumes.

✓(D) have any of the properties listed above.

[illegible]

---

12. A super-insulated house is at a temperature of 20°C. The temperature outside is 0°C. The surface area of the house is 200 m^2, and the emissivity is 1. Approximately how much energy is radiated (in W) per second? (Stefan-Boltzmann constant, $\sigma = 5.7\times10^{-8}$W/m^{2}K^4)

✓(A) 20000 20,700

(B) 2000 2070

(C) 200 207

(D) 20 27

$T_{en} = 0 + 273 = 273\ K$

$T = 20 + 273 = 293\ K$

$$H = \varepsilon \sigma A (T^4 - T_{en}^4)$$

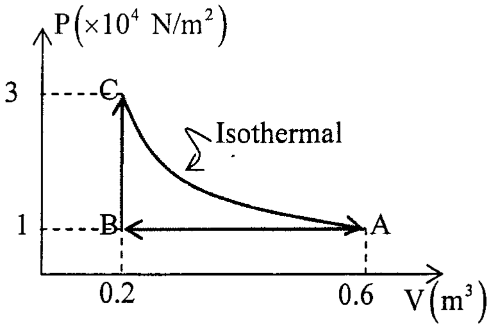
$$= (1)(5.7\times10^{-8})(200)(293^4 - 273^4)$$

$$= 20,696 \quad W$$

13. An ideal gas in a chamber passes through the cycle shown below. The process C to A is an isothermal process. Determine the efficiency of the system.

$PV = nRT$

$T = \frac{PV}{nR}$



(A) 10.11 %
[✓ (B) 15.62 %]
(C) 18.98 %
(D) 20.30 %

$W_{BC} = 0$

$W_{CA} = nRT \ln\left(\frac{0.6}{0.2}\right) = PV \ln\left(\frac{0.6}{0.2}\right)$

$= (0.6\times10^4) \ln\left(\frac{0.6}{0.2}\right) = 6591.67 \text{ J}$

$W_{AB} = P\Delta V = 1\times10^4(0.2-0.6) = -4000 \text{ J}$

$W_{net} = 2591.67 \text{ J}$

$Q_{BC} = nC_v(T_C - T_B) = \frac{n\frac{3}{2}R(3\times10^4\times0.2 - 1\times10^4\times0.2)}{nR} = 10{,}000 \text{ J}$

$Q_{CA} = W_{CA} = 6591.67 \text{ J}$

$Q_{AB} = nC_p(T_B - T_A) = \frac{n\frac{7}{2}R(0.2\times1\times10^4 - 0.6\times10^4)}{nR} = -14{,}000 \text{ J}$

$Q_{net} = 2591.67 \text{ J}$ ✓ $\quad \eta = \frac{W}{Q_{in}} = 15.62\%$

---

14. Two ideal monatomic gases are in thermal equilibrium with each other. Gas A is composed of molecules with mass *m* while gas B is composed of molecules with mass 4*m*. The ratio of the average molecular speeds v_A/v_B is:
A) 1/4
B) 1/2
C) 1
[✓ D) 2]

$\frac{1}{2} m v_A^2 = \frac{3k_B}{2} T \quad -①$

$\frac{1}{2} 4m v_B^2 = \frac{3k_B}{2} T \quad -②$

$\frac{①}{②} \quad \frac{m v_A^2}{4m v_B^2} = 1$

$\frac{v_A}{v_B} = 2$

✱ 17. Determine the change in entropy (in J/K) when 5.00 moles of an ideal gas at 0°C are compressed isothermally from an initial volume of 100 cm^3 to a final volume of 20 cm^3.

[✓ (A) -67]
(B) -82
(C) -101
(D) -115

isothermal process $\Delta U = Q - W$

$Q = W$

$$w = \int P\,dV = \int \frac{nRT}{V}\,dV = nRT \ln\left(\frac{V_f}{V_i}\right) = (5)(8.314)(273)\ln\left(\frac{20}{100}\right)$$

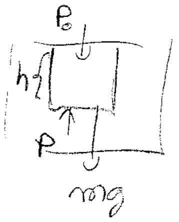
$$W = -18,264.88 = Q$$

$$\Delta S = \frac{Q}{T} = -67$$

---

18. Some species of whales can dive to depths of one kilometer. What is the total pressure they experience at this depth? (ρ_{sea} = 1 020 kg/m^3 and 1.01 × 10^5 N/m^2 = 1 ATM.)

(A) 80 ATM
(B) 90 ATM
[✓ (C) 100 ATM]
(D) 110 ATM



$$\Sigma F = 0$$

$$PA - P_0 A - mg = 0$$

$$PA = P_0 A + mg$$

$$P = P_0 + \frac{m}{A} g = P_0 + \frac{\rho V}{A} g$$

$$P = P_0 + \rho g h$$

$$= 1.01 \times 10^5 + 1020 \times 9.8 \times 1000$$

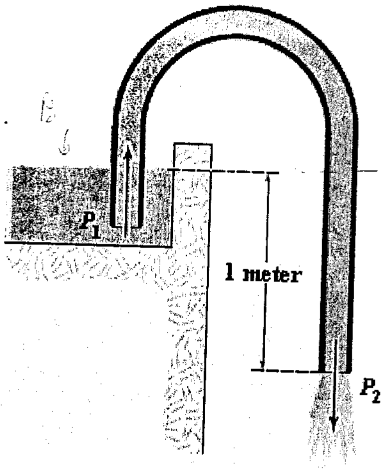
$$= 10.097 \times 10^6 \text{ Pa}$$

$$= 99.97 \text{ ATM}$$

$$\simeq 100 \text{ ATM}$$

---

19. The siphon shown is used to transfer liquid from a higher level to a lower level. If the fluid is drawn up and is continuous through the tube, determine the velocity of flow of gasoline if the vertical distance from the liquid surface to the outlet is 1.0 m.



(A) 2.2 m/s
(B) 3.3 m/s
[✓ (C) 4.4 m/s]
(D) 5.5 m/s

$$\cancel{P_1} + \overset{0}{\cancel{\tfrac{1}{2}\rho v_1^2}} + \overset{0}{\cancel{\rho g y_1}} = \cancel{P_2} + \tfrac{1}{2}\rho v_2^2 + \rho g y_2$$

$$\tfrac{1}{2}\cancel{\rho} v_2^2 = \overset{0}{\cancel{P_1 - P_2}} - \cancel{\rho} g y_2$$

$$v_2 = \sqrt{-2 g y_2}$$

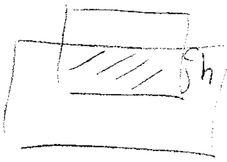
$$= \sqrt{-2(9.8)(-1)}$$

$$v_2 = 4.4 \text{ m/s}$$

---

20. A cube of water ice ($\rho = 0.917 \times 10^3$ kg/m^3) is placed in mercury ($\rho = 13.6 \times 10^3$ kg/m^3), which is liquid at 0° Celsius. If we ignore any possible melting of the ice cube and problems with the surface tension of mercury, the fraction of the ice cube that floats above the surface of the mercury is

[✓ (A) 0.933]
(B) 0.901
(C) 0.875
(D) 0.652



$$m_{mer} g = m_{ice} g$$

$$\rho V_{mer} \cancel{g} = \rho_{ice} V_{ice} \cancel{g}$$

$$\frac{V_{mer}}{V_{ice}} = \frac{\rho_{ice}}{\rho_{mer}}$$

$$= \frac{0.917 \times 10^3}{13.6 \times 10^3}$$

$$= 0.0674$$

above $= 1 - 0.0674 = 0.933$
