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General Physics I, Final-1
PHYS1000AA, Class year104
2016-01-07, Thursday

Quiz-Final-1

1. Solution:

$$(a) F = -kx = ma_x$$

$$a_x = -\frac{k}{m}x$$

$$a_x = \frac{dV_x}{dt} = \frac{d}{dt}(\frac{dx}{dt}) = \frac{d^2x}{dt^2} = -\frac{k}{m}x$$

$$\therefore \frac{d^2x(t)}{dt^2} = -\frac{k}{m}x$$

$$\therefore \frac{d^2x(t)}{dt^2} + \frac{k}{m}x = 0$$

$$(b) F_T = -mg\sin\theta = mas = m\frac{d^2S}{dt^2}$$

$$Where, S = L\theta \qquad \therefore \frac{d^2S}{dt^2} = L\frac{d^2\theta}{dt^2}$$

$$\Rightarrow -mg\sin\theta = mL\frac{d^2\theta}{dt^2}$$

$$\therefore \frac{d^2\theta}{dt^2} = -(\frac{g}{L})\sin\theta$$

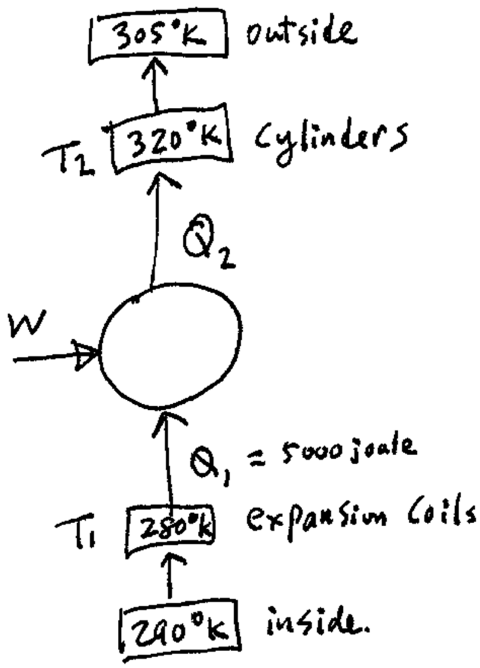
(c)In this figure , S=Rθ , $\therefore \theta = \frac{S}{R} \Rightarrow \ddot{\theta} = \frac{\ddot{S}}{R}$

$$\ddot{\theta} + (\frac{g}{L})\theta = 0$$

$$\frac{\ddot{S}}{R} + (\frac{g}{L})\frac{S}{R} = 0$$

$\therefore \ddot{S} + (\frac{g}{L})S = 0,$ this is the same a in (a). So they both are Simple Harmonic Oscillators

2. Solution:



Schemically. All components are showing at the above.

(a) The efficiency η of a reversible heat engine

$$\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = \frac{T_1 - T_2}{T_1} \quad \text{— heating}$$

$$\eta = \frac{W}{Q_2} = \frac{Q_2 - Q_1}{Q_2} = \frac{T_2 - T_1}{T_2} \quad \text{— cooling}$$

$$\therefore \text{for Cooling} \quad \eta = 1 - \frac{280}{320} = 0.125 = \frac{Q_2 - Q_1}{Q_2} = \frac{Q_2 - 5000J}{Q_2}$$

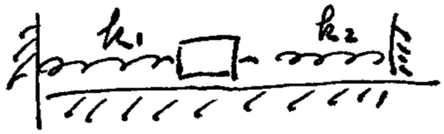
$$\therefore Q_2 = 5715\,J \quad \Rightarrow \underline{W = \eta \cdot Q_2 = 0.125 \times 5715 \simeq 715\,J}$$

(b)

$$\Delta S = \frac{Q_2}{T_{out}} - \frac{Q_2}{T_{cylinder}} = Q_2 \left[\frac{1}{305} - \frac{1}{320} \right]$$

$$= 0.88\ J/°K$$

3. Solution:



$$\Delta x_1 = -\Delta x_2 .$$

if we generate a displacement Δx, then

$$\Delta x_1 = \Delta x$$
$$\Delta x_2 = -\Delta x$$

$$F = -k_1 \Delta x_1 - (-k_2 \Delta x_2) = -k_1 \Delta x + k_2 (-\Delta x)$$
$$= -(k_1 + k_2)\Delta x$$
$$= -k' \Delta x \quad , \; k' = k_1 + k_2 .$$

$$\nu = \frac{1}{2\pi}\sqrt{\frac{k'}{m}} = \frac{1}{2\pi}\sqrt{\frac{k_1+k_2}{m}}$$

4. Solution:

Adiabatic process for an ideal gas

$$Q = 0 .$$

$$\Delta E_{int} = Q + W = \overset{W}{\cancel{Q}} = nC_v dT = -pdV$$

But $pV = nRT$

$$pdV + Vdp = nRdT$$
$$= -\frac{R}{C_v} pdV$$

$$\frac{dV}{V} + \frac{dp}{p} = -\left(\frac{C_p - C_v}{C_v}\right)\frac{dV}{V}$$
$$= (1-\gamma)\frac{dV}{V}$$

$$\frac{dp}{p} + \gamma \frac{dV}{V} = 0$$

$$\ln p + \gamma \ln V = \text{Constant}$$

$$pV^{\gamma} = \text{constant}$$

5. Solution:

Let $y_1 = A\sin(kx - wt)$ traveling to the right

$y_2 = A\sin(kx + wt)$ traveling to the left

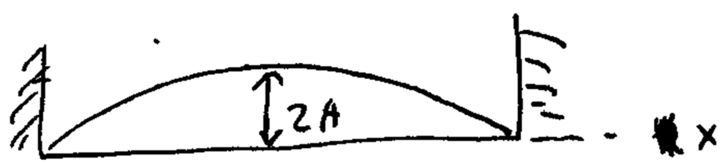
The resulting wave is

(a) $y = y_1 + y_2 = A\sin(kx - wt) + A\sin(kx + wt)$

$= \underline{2A\sin(kx)\cos(wt)}$

(b) You have a new wave

$$y = \underbrace{2A\sin(kx)}_{\text{Amplitude}}\ \underbrace{\cos(wt)}_{\text{Oscillation}}$$



the wave form oscillates as a function of $\cos(wt)$. it is not traveling anymore it stands there. So it is called Standing Wave.

6. Solution :

(a) The absolute pressure is

$P = P_0 + h\rho g$,Where P_0 is the air pressure and $h = 2.0km, \rho = 1000kg/m^3,\ g\ = 9.8m/s^2$

$\therefore P = 100000Pa + (2000m \times 1000kg/m^3 \times 9.8m/s^2) = 1.97 \times 10^7\,Pa$

(b)The gauge pressure is the difference in pressure between the water outside and the air inside the submarine, which we suppose is at 1.00 atmosphere.

$\therefore P_{gauge}\ =\ P\ -\ P_0\ =\ h\rho g = 1.96 \times 10^7\,Pa$

The resultant inward force on the window is then

$F = P_{gauge}A = 1.96 \times 10^7\,Pa \times \pi r^2 = 1.96 \times 10^7\,Pa \times 3.14 \times (2.0)^2 = 2.5 \times 10^8\,N$

7. Solution:

(a) Kepler's third law of planetary motion is

$T^2 = \ K_S a^3$, where T is period of planeatary revolution , $a\ =$ The semimajor axis length of orbit

and $\mathrm{K}_S =$ constant of proportionality (with respect to Sun)

(b) From figure we can find the major axis length of the orbit is

$2a = \ 2.5 \quad \therefore a = 1.25$ AU

and a+c= 2.0 $\quad \therefore c = 0.75$ AU , where c is the distance between focus and the center of orbital axis

$\therefore$ ecentricity $e = \dfrac{c}{a} = \dfrac{0.75}{1.25} = 0.66$

(c)We know that $T^2 = \ K_S a^3$

So $\quad T = \sqrt{K_S a^3} \ = a\sqrt{K_S a} = 1.25 \text{ AU} \times \sqrt{2.97 \times 10^{-19} \times 1.25 \text{ AU}}$

$= 1.25\ \times 1.496x10^{11} \times \sqrt{2.97 \times 10^{-19} \times 1.25\ \times 1.496x10^{11}}$

$= 55165000 \text{ seconds} = \dfrac{55165000\ days}{3600 \times 24} = 638.5\ days = 1.78 years$