國立東華大學

Department of Physics
National Dong Hwa University, 1, Sec. 2,
Da Hsueh Rd., Shou-Feng, Hualien, 974, Taiwan

General Physics I, Final 1
PHYS10000AA, AB, AC, Class year 106
01-18-2018

SN:______________, Name:________________

Final 1 Solution

Chapter 12-19, Serway; ABSOLUTELY NO CHEATING!

Please write the answers on the blank space or on the back of this paper to save resources.

1. (a) $F = -kx = ma_x$, $a_x = -\frac{k}{m}x$

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

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

(b) $F_t = -mg\sin\theta = ma_s = m\frac{d^2s}{dt^2}$

$$s = L\theta \rightarrow \frac{d^2s}{dt^2} = L\frac{d^2\theta}{dt^2}$$

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

if θ is small, $\sin\theta \approx \theta$

$$\rightarrow -mg\theta = L\frac{d^2\theta}{dt^2}$$

$$\therefore \frac{d^2\theta}{dt^2} + \left(\frac{g}{L}\right)\theta = 0$$

, This is the same as that of the spring-mass system.

(c) $s = L\theta \quad \therefore \frac{d^2s}{dt^2} = L\frac{d^2\theta}{dt^2}$

The above equation can be rewritten to

$$\frac{1}{L}\frac{d^2s}{dt^2} + \left(\frac{g}{L}\right)\frac{s}{L} = 0 \rightarrow \frac{d^2s}{dt^2} + \left(\frac{g}{L}\right)s = 0$$

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2. (a) Speed of the wave
Use the figure

$$F_r = 2T\sin\theta \simeq 2T\theta \quad \text{if } \theta \text{ is small}$$

$$m = \mu\Delta S = \mu R 2\theta = 2\mu R\theta$$

But $F_r = ma = \frac{mv^2}{R} = 2T\theta = \frac{2\mu R\theta v^2}{R}$

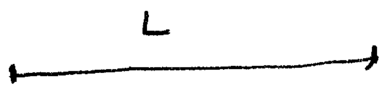
$$\therefore\ v = \sqrt{\frac{T}{\mu}}$$

(b) $y_1 = A\sin(kx-\omega t)\ ;\ y_2 = A\sin(kx+\omega t)$

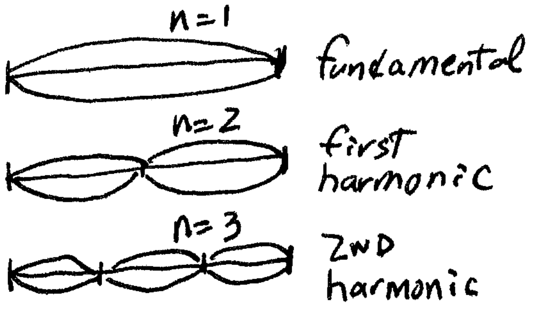
$$y_{\text{total}} = y_1 + y_2 = A\sin(kx-\omega t) + A\sin(kx+\omega t)$$

$$= \underbrace{2A\sin(kx)}_{\text{New amplitude} - ②}\cos(\omega t) \quad -①$$

(c)



$\Rightarrow$



$\lambda_n = \frac{2L}{n}$. n= 1.2,3 ···

$f_n = \frac{v}{\lambda}$ $\therefore f_n = \frac{v}{\lambda_n} = n\frac{v}{2L}$

n= 1.2,3 (or. 1. 2. 3)

$f_n = \frac{v}{\lambda_n} = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$ $f_1 = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$, $f_2 = \frac{2}{2L}\sqrt{\frac{T}{\mu}}$, $f_3 = \frac{3}{2L}\sqrt{\frac{T}{\mu}}$

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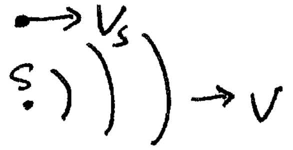
3, Doppler effect

Sound frequency f, speed v

Now, the detector is stationary. Source moves towards the detector with a speed V_s



During a time period T.

Wave front moves vT. (W_1)

Source moves V_sT (W_2)

In this time period, the two wave fronts (W_1 and W_2) separate by a distance $(vT - V_sT)$ and this is the detected new wave length λ' of the wave due to the moving of the Source,

$$\therefore f' = \frac{v}{\lambda'} = \frac{v}{vT - V_sT}$$

$$= \frac{v}{\frac{v}{f} - \frac{V_s}{f}} = f\left(\frac{v}{v - V_s}\right)$$

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4. gravitational force

$$F = G\frac{M_1M_2}{r^2} , G = 6.67\times10^{-11}\ m^3\,kg^{-1}s^{-2}$$

$$\rightarrow r = \sqrt{G\frac{M_1M_2}{F}} = \sqrt{6.67\times10^{-11}\frac{m^3}{kg\,s^2}\cdot\frac{2\times10^{50}\,kg\times3\times10^{50}\,kg}{6\times10^{25}\,N}}$$

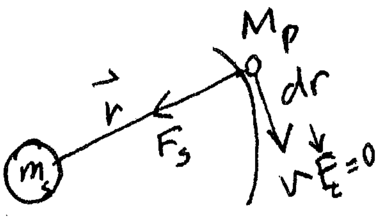
$$= 2.58\times10^{8}\ m$$

5 (a) "1. All planets are in elliptical orbits

2. The radius vector drawn from the Sun to a planet sweeps out equal areas in equal time intervals

3. The square of the orbital period is proportional to the cube of the semi major axis of the orbit

(b)



$$\vec{\tau} = \vec{r}\times\vec{F} = r\times F(r)\,\hat{r} = 0$$ No force in the direction of planet

$$\tau = \frac{dL}{dt} = 0 \rightarrow L = \text{constant}$$

$$L = r\times p = M_p\,\vec{r}\times\vec{v} = \text{constant}$$

$$dA = \frac{1}{2}|\vec{r}\times d\vec{r}| = \frac{1}{2}|\vec{r}\times\vec{v}dt| = \frac{L}{2M_p}dt$$

$$\frac{dA}{dt} = \frac{L}{2M_p} = \text{constant}$$

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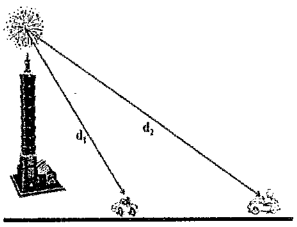
6. The sound intensity at distance d_1 is, suppressing units,

$$I_1 \frac{\Delta P_{\max}^2}{2\rho v} = \frac{(20)^2}{2(1.20)(332)} = 0.5\,\mathrm{W/m^2}$$

If air does not absorb sound energy, the intensity of sound is inversely proportional to the square of the distance from its source. The intensity at distance d_2 is

$$\begin{aligned} I_2 &= \left(\frac{d_1}{d_2}\right)^2 I_1 = \left(\frac{1000\,\mathrm{m}}{4000\,\mathrm{m}}\right)^2 I_1 = \frac{1}{16}\left(0.5\,\mathrm{W/m^2}\right) \\ &= 3.1\times10^{-2}\,\mathrm{W/m^2} \end{aligned}$$

which has an intensity level of



$$\begin{aligned} \beta_2 &= (10\ \mathrm{dB})\log\left(\frac{I_2}{I_0}\right) = (10\ \mathrm{dB})\log\left(\frac{3.1\times10^{-2}\,\mathrm{W/m^2}}{10^{-12}\,\mathrm{W/m^2}}\right) \\ &= 100.4\ \mathrm{dB} \end{aligned}$$

Allowing for absorption of the wave over the distance traveled,

$$\beta_2' = \beta_2 - (10\,\mathrm{dB/km})(4000m - 1000\mathrm{m}) = 74.0dB$$