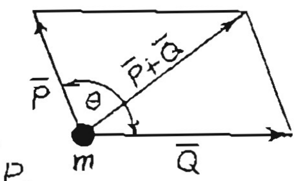
ISBN: 0-13-710005-1

Printed in the United States of America

CHAPTER 1

1-1. Let $Q > P$.



$a_{max} = \frac{1}{m}(Q+P)$, $a_{min} = \frac{1}{m}(Q-P)$

$\frac{a_{max}}{a_{min}} = \frac{Q+P}{Q-P} = 3$, giving $Q = 2P$.

$F = ma$, $a = \frac{F}{m}$

Mean acceleration $= \frac{1}{2}(a_{max}+a_{min}) = \frac{Q}{m} = \frac{1}{m}|\bar{P}+\bar{Q}|$

Hence $Q = |\bar{P}+\bar{Q}|$. By cosine law, $|\bar{P}+\bar{Q}|^2 = Q^2+P^2+2QP\cos\theta = Q^2$

Then $P^2 = -2QP\cos\theta = -4P^2\cos\theta$ or $\cos\theta = -1/4$, $\underline{\theta = 104.48°}$

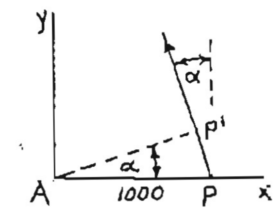
1-2. (a) Auto position $\bar{r}_a = 30t\,\bar{i}$ meters

Plane position $\bar{r}_p = 1000\,\bar{i} + 90t\,\bar{j} + 1000\,\bar{k}$ meters

Relative position $\bar{r}_{p/a} = \bar{r}_p - \bar{r}_a = (1000-30t)\bar{i} + 90t\,\bar{j} + 1000\,\bar{k}$

Relative velocity $\bar{v}_{p/a} = \frac{d}{dt}(\bar{r}_{p/a}) = \underline{-30\,\bar{i} + 90\,\bar{j}\ \text{m/sec}}$

(b) $AP' = 1000\cos\alpha$, $\alpha = \tan^{-1}\frac{1}{3}$



or $AP' = 1000\,\frac{3}{\sqrt{10}}$

Separation $d_{min} = \sqrt{(AP')^2 + 1000^2}$

$= 1000\sqrt{\frac{9}{10}+1}$

$= \underline{1378.4 \text{ meters}}$

1-3. Given $\bar{e}_1 = l_1\bar{i} + l_2\bar{j} + l_3\bar{k}$

$\bar{e}_2 = m_1\bar{i} + m_2\bar{j} + m_3\bar{k}$

$\bar{e}_3 = n_1\bar{i} + n_2\bar{j} + n_3\bar{k}$

(a) $l_1^2 + l_2^2 + l_3^2 = 1$

$m_1^2 + m_2^2 + m_3^2 = 1$

$n_1^2 + n_2^2 + n_3^2 = 1$

(b)

$$\bar{e}_1 \cdot (\bar{e}_2 \times \bar{e}_3) = \begin{vmatrix} l_1 & l_2 & l_3 \\ m_1 & m_2 & m_3 \\ n_1 & n_2 & n_3 \end{vmatrix} = 0$$

(c) Equations of part (a) and

$l_1m_1 + l_2m_2 + l_3m_3 = 0$

$l_1n_1 + l_2n_2 + l_3n_3 = 0$

$m_1n_1 + m_2n_2 + m_3n_3 = 0$

4. $\bar{A} = A_x \bar{i} + A_y \bar{j} + A_z \bar{k}$

$= A_1 \bar{e}_1 + A_2 \bar{e}_2 + A_3 \bar{e}_3$ where $\begin{cases} \bar{e}_1 = \bar{i} \\ \bar{e}_2 = \frac{1}{\sqrt{2}}(\bar{i}+\bar{j}) \\ \bar{e}_3 = \frac{1}{\sqrt{2}}(\bar{i}+\bar{k}) \end{cases}$

quating $\bar{i}$ components,

$$\left.\begin{aligned} A_1 + \frac{A_2}{\sqrt{2}} + \frac{A_3}{\sqrt{2}} &= A_x \\ \text{rom } \bar{j} \text{ components, } \frac{A_2}{\sqrt{2}} &= A_y \\ \text{rom } \bar{k} \text{ components, } \frac{A_3}{\sqrt{2}} &= A_z \end{aligned}\right\} \text{solving,} \quad \begin{aligned} A_1 &= A_x - A_y - A_z \\ A_2 &= \sqrt{2}\, A_y \\ A_3 &= \sqrt{2}\, A_z \end{aligned}$$

-5. Given $[L], [M], [F]$ are fundamental.

$= ma$, so the dimensions of acceleration $[A] = [M^{-1} F]$

$A] = [L T^{-2}]$ or $[T] = [L^{\frac{1}{2}} A^{-\frac{1}{2}}] = [L^{\frac{1}{2}} M^{\frac{1}{2}} F^{-\frac{1}{2}}]$

-6. Fundamental units: mass — kg, length — ell, time — tee

et 1 ell = a meters

1 tee = b sec

Density of water $\rho = 1\ g/cm^3 = 1000\ kg/m^3$

Specific wt. $w = \rho g = 9810 \frac{kg}{m^2 sec^2} = 1 \frac{kg}{ell^2\, tee^2}$

Hence $1 = 9810 \left(\frac{ell}{m}\right)^2 \left(\frac{tee}{sec}\right)^2 = 9810\, a^2 b^2$

Accel. of gravity $= 9.81 \frac{m}{sec^2} = 1 \frac{ell}{tee^2}$ or $9.81 = \frac{a}{b^2}$

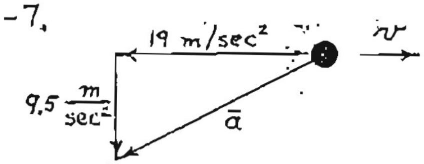
Multiply equations. $9.81 = 9810\, a^3$ giving $a = 0.1$

Then $b = \sqrt{\frac{a}{9.81}} = \frac{1}{\sqrt{98.1}} = 0.1010$

1 ell = 0.1000 meters

1 tee = 0.1010 sec

1-7.

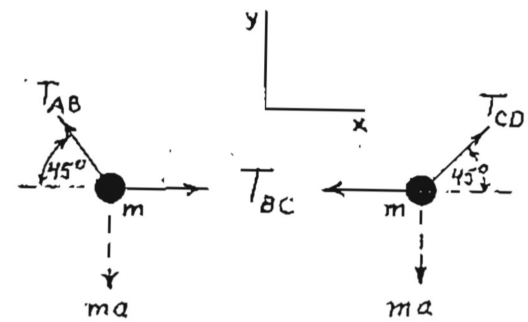


$a = \sqrt{19^2 + 9.5^2} = 21.243 \frac{m}{sec^2}$

For $v = 3000$ m/sec,

$\omega v = 9.5 \frac{m}{sec^2}$, $\omega = \frac{9.5}{3000} = 3.167 \times 10^{-3} \frac{rad}{sec}$

1-8. Use d'Alembert's principle.

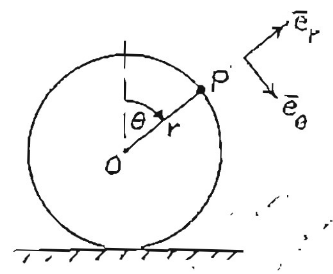


Sum y forces on system. $\frac{1}{\sqrt{2}}(T_{AB} + T_{CD}) = 2ma$

Sum x forces on each particle, $T_{BC} = \frac{T_{AB}}{\sqrt{2}} = \frac{T_{CD}}{\sqrt{2}}$

Then $T_{AB} = T_{CD} = \sqrt{2}\, ma$, $T_{BC} = ma$

CHAPTER 2



2-1. $\omega = \alpha t$ where $\alpha = \text{const.}$

Integrate to obtain $\theta = \frac{1}{2}\alpha t^2$

Acceleration of P is

$$\bar{a} = \bar{a}_o + \bar{a}_{P/O}$$

where the horizontal acceleration $\bar{a}_o = r\alpha(\sin\theta\, \bar{e}_r + \cos\theta\, \bar{e}_\theta)$

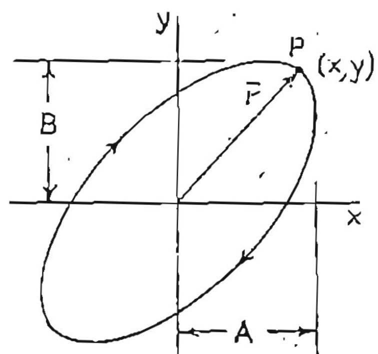
P moves in a circular path relative to O.

$$\bar{a}_{P/O} = -r(\alpha t)^2 \bar{e}_r + r\alpha\, \bar{e}_\theta$$

Hence. $\underline{\bar{a} = r\alpha\left[(\sin\theta - \alpha t^2)\bar{e}_r + (1+\cos\theta)\bar{e}_\theta\right]}$

2-2. Given $x = A\cos\omega t$

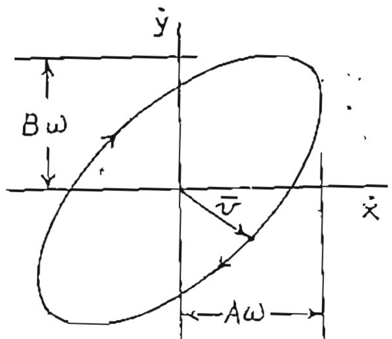
$y = B\cos(\omega t + \beta)$



Then $\dot{x} = -A\omega \sin\omega t$

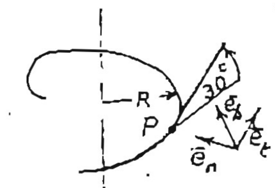
$\dot{y} = -B\omega \sin(\omega t + \beta)$

The hodograph is a plot of $\bar{v} = \dot{x}\bar{i} + \dot{y}\bar{j}$



Note that the two ellipses have the same shape.

2-3. Speed $s = v_0$ and $\dot{s} = a_o$



$$\bar{a} = \ddot{s}\,\bar{e}_t + \frac{\dot{s}^2}{\rho}\bar{e}_n$$

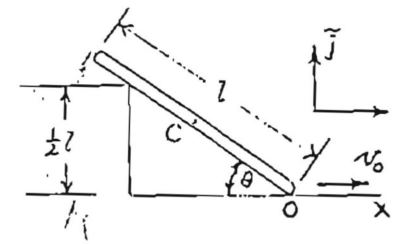
From Eq. (2-61), $\rho = R(1+k^2)$

$= R(1+\tan^2 30°) = \frac{4}{3}R$

Then we obtain $\underline{\bar{a} = a_o \bar{e}_t + \frac{3v_0^2}{4R}\bar{e}_n}$

2nd method: Use the horizontal component of velocity and a circular path of radius R to obtain $a_n = \frac{(v_0\cos 30°)^2}{R} = \frac{3v_0^2}{4R}$

2-4. Position x of lower end O is



$x = \frac{1}{2}l\cot\theta$

giving $\dot{x} = -\frac{1}{2}l\dot{\theta}\csc^2\theta = v_0$

or $\underline{\dot{\theta} = -\frac{2v_0}{l}\sin^2\theta}$

(b) Differentiate again. $\ddot{\theta} = \frac{-4v_0\dot{\theta}}{l}\sin\theta\cos\theta$

Using $\dot{\theta}$ expression, $\underline{\ddot{\theta} = \frac{8v_0^2}{l^2}\sin^3\theta\cos\theta}$

(c) $\bar{v}_c = \bar{v}_0 + \bar{v}_{c/o} = v_0\bar{i} + \frac{1}{2}l\dot{\theta}(\sin\theta\,\bar{i} + \cos\theta\,\bar{j})$

$= v_0\bar{i} + \frac{1}{2}l\left(\frac{-2v_0}{l}\sin^2\theta\right)(\sin\theta\,\bar{i} + \cos\theta\,\bar{j})$

or $\underline{\bar{v}_c = v_0\left[(1-\sin^3\theta)\bar{i} - \sin^2\theta\cos\theta\,\bar{j}\right]}$