(1) $\boxed{\text{RHK4Q8}}$ $y = A(x-vt)$ $y = A(x+vt)^2$
$y = A\sqrt{x-vt}$ $y = A\ln(x+vt)$

These are, in general, unbounded in y... y can go to $-\infty$ and up to $+\infty$.. real waves generally cannot have amplitudes so large. In addition $\sqrt{x-vt}$ and $\ln(x+vt)$ are complex-valued for $x-vt<0$ or $x+vt<0$, which is peculiar.. sometimes the real part of y is interpreted as the actual amplitude, though

(2) $\boxed{\text{RHK4P2}}$ (a) $\boxed{\nu = \frac{12}{30} = \frac{2}{5} = 0.4 \text{ Hz}}$

(b) $\boxed{v = \frac{15 \text{ m}}{5 \text{ s}} = 3 \text{ m/s}}$

(c) $\lambda\nu = v$

$$\boxed{\lambda = \frac{v}{\nu} = \frac{3 \text{ m/s}}{0.4 \text{ 1/s}} = 7.5 \text{ m}}$$

(3) $\boxed{\text{RHK4P6}}$ $\cos(kx - \omega t)$

$$\nu\lambda = v$$

$\nu = 493$ Hz
$v = 353$ m/s

$$\lambda = \frac{v}{\nu} = \frac{353 \text{ m/s}}{493 \text{ 1/s}} = 0.716 \text{ m}$$

$$k = \frac{2\pi}{\lambda} = \frac{2\pi}{0.716} = 8.78 \text{ 1/m}$$

(a) t = same

phase = $55^\circ = \frac{\pi}{180} \cdot 55 = 0.96$ rad

$k\Delta x = 0.96$ rad

$$\boxed{\Delta x = \frac{0.96 \text{ rad}}{8.78\ 1/m} = 0.109\ m}$$

(b) $\omega = 2\pi\nu = 2\pi \cdot 493\ 1/s$

$\omega = 3098$ rad/s

$$\boxed{\begin{aligned} \text{phase} &= \omega\Delta t = 3098 \cdot 1.12 \cdot 10^{-3} \\ &= 3.47 \text{ radians} \\ \text{phase} &= \frac{180}{\pi} \cdot 3.47 = 199^\circ \end{aligned}}$$

Extra | RHK4 P7

NOT ASSIGNED

(a) $y(x,t) = y_m \sin(kx - \omega t - \phi)$

$\frac{\partial y}{\partial t} = y_m \underbrace{\cos(kx - \omega t - \phi)(-\omega)}_{\text{maximum } \cos = -1 \ldots}$

$$\boxed{\left(\frac{\partial y}{\partial t}\right)_{max} = \omega y_m}$$

(b) $\frac{\partial^2 y}{\partial t^2} = -\omega y_m(-\sin(kx - \omega t - \phi)(-\omega)) \xrightarrow{\text{Maximum}} = \omega^2 y_m$

4) RHK4 P9

a) $y = 6.0 \sin(0.020\pi x + 4\pi t)$

$y_m = 6.0\ cm$

$k = 0.020\pi \qquad \omega = 4\pi$

$\boxed{\text{amplitude} = y_m = 6.0\ cm}$

b) $k = \frac{2\pi}{\lambda} = 0.020\pi$

$\boxed{\lambda = \frac{2}{0.02} = 100\ cm}$

c) $\boxed{\nu = \frac{\omega}{2\pi} = \frac{4\pi}{2\pi} = 2\ 1/s = 2\ Hz}$

d) $\boxed{\lambda\nu = \text{speed} = 200\ cm/s}$

e) + sign → right to left

or $0.020\pi x + 4.0\pi t = \text{constant}$

$0.020\pi\ v + 4.0\pi = 0$

$v = \frac{-4.0}{0.02} = -200\ \frac{cm}{s}$

− velocity is right to left

f) problem 7 → $u_{max} = \omega y_m$

$\boxed{u_{max} = 4\pi \cdot 6 = 24\pi\ cm/s = 75.4\ cm/s}$

(5) RHK4 P10

$$\mu = \frac{0.625\ \text{kg}}{2.15\ \text{m}} = 0.291\ \text{kg/m}$$

$$F = 487\ \text{N} = 487\ \frac{\text{kg}\cdot\text{m}}{\text{s}^2}$$

$$\boxed{v = \sqrt{\frac{F}{\mu}} = \sqrt{\frac{487\ \frac{\text{kg}\cdot\text{m}}{\text{s}^2}}{0.291\ \text{kg/m}}} = 40.9\ \frac{\text{m}}{\text{s}}}$$

(6) RHK4 P17

$$u_{max} = \frac{\partial y}{\partial t} = y_m \underbrace{(\sin(kx-\omega t)(-\omega))}_{max\ =\ \omega}$$

$$\frac{u_{max}}{v} = \frac{\omega y_m}{v}$$

$$\frac{u_{max}}{v} = \underbrace{\omega y_m}_{\text{independent variables, can be chosen independent of } \mu, F} \sqrt{\frac{\mu}{F}}$$

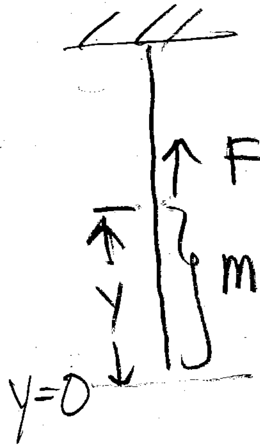
independent variables, can be chosen independent of μ, F

does depend on what the cord is made of

(7) RHK4 P22

Key point: tension F depends on y...

(a)



$$F = \mu y g$$

$$v = \sqrt{\frac{F}{\mu}} = \sqrt{\frac{\mu y g}{\mu}}$$

$$\boxed{v = \sqrt{yg}}$$

(b) $dy = v\,dt$ — v is a function of y!

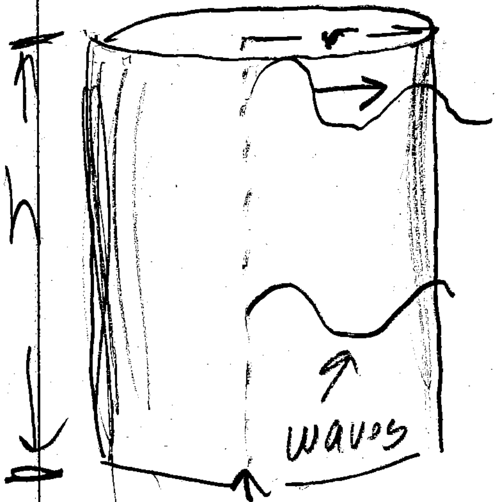
$$\frac{dy}{v} = dt'$$

$$\int_0^L \frac{dy}{\sqrt{yg}} = \int_0^t dt' = t$$

$$= \frac{1}{\sqrt{g}}\, 2\sqrt{y}\,\Big|_0^L = \boxed{2\sqrt{\frac{L}{g}} = t}$$

(c) NO!

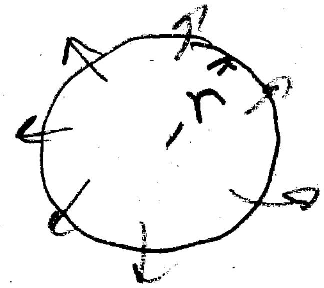
8 PHYK4 P26



← waves, look from above!

Source Emits Power

$P \propto h$



← Power through circle is constant

$I \cdot \text{Area} = \text{Power}$

$I \cdot 2\pi r \cdot h = \text{Power}$

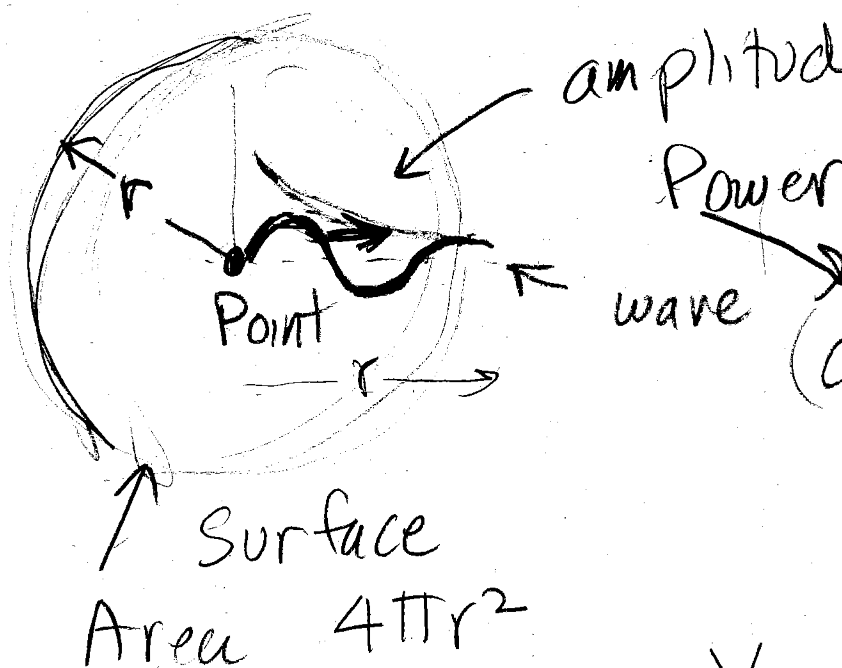
a $\boxed{I \propto \frac{1}{r}}$

b $I \propto y_m^2 \propto \frac{1}{r}$

$$\boxed{y_m \propto \frac{1}{\sqrt{r}}}$$

8 RHK4 P27

(a) Idea is that Power passing through a pertinent boundary is constant.. in 3-dimensions the.. boundary is a spherical surface



$$(\text{constant})_1 \, y_m^2 \, (\text{Area}) = (\text{another constant})_2$$

$$y_m \propto \sqrt{\frac{1}{4\pi r^2}}$$

$$y_m \propto \frac{1}{r}$$

More generally,

Power $\propto v$ (speed)

$\propto \omega^2$

$\propto \rho$ (mass/volume)

Dimensionally, then, check.

$$\text{Power} = \frac{\text{Energy}}{\text{time}} = \frac{\text{mass}\cdot l^2}{\text{time}^3} \stackrel{?}{=} \underset{\frac{l}{\text{time}}}{V} \cdot \underset{\frac{1}{\text{time}^2}}{\omega^2} \cdot \underset{\frac{m}{l^3}}{\rho} \cdot \underbrace{Y_m^2 \cdot A}_{l^4}$$

$$\frac{m \cdot l^2}{t^3} \stackrel{?}{=} \frac{m l^2}{t^3} \checkmark$$

so, $(\text{constant})_1 \propto V \omega^2 \rho$

and $Y_m = \dfrac{Y}{r}$, but

(b) dimensions of Y must be $(\text{length})^2$

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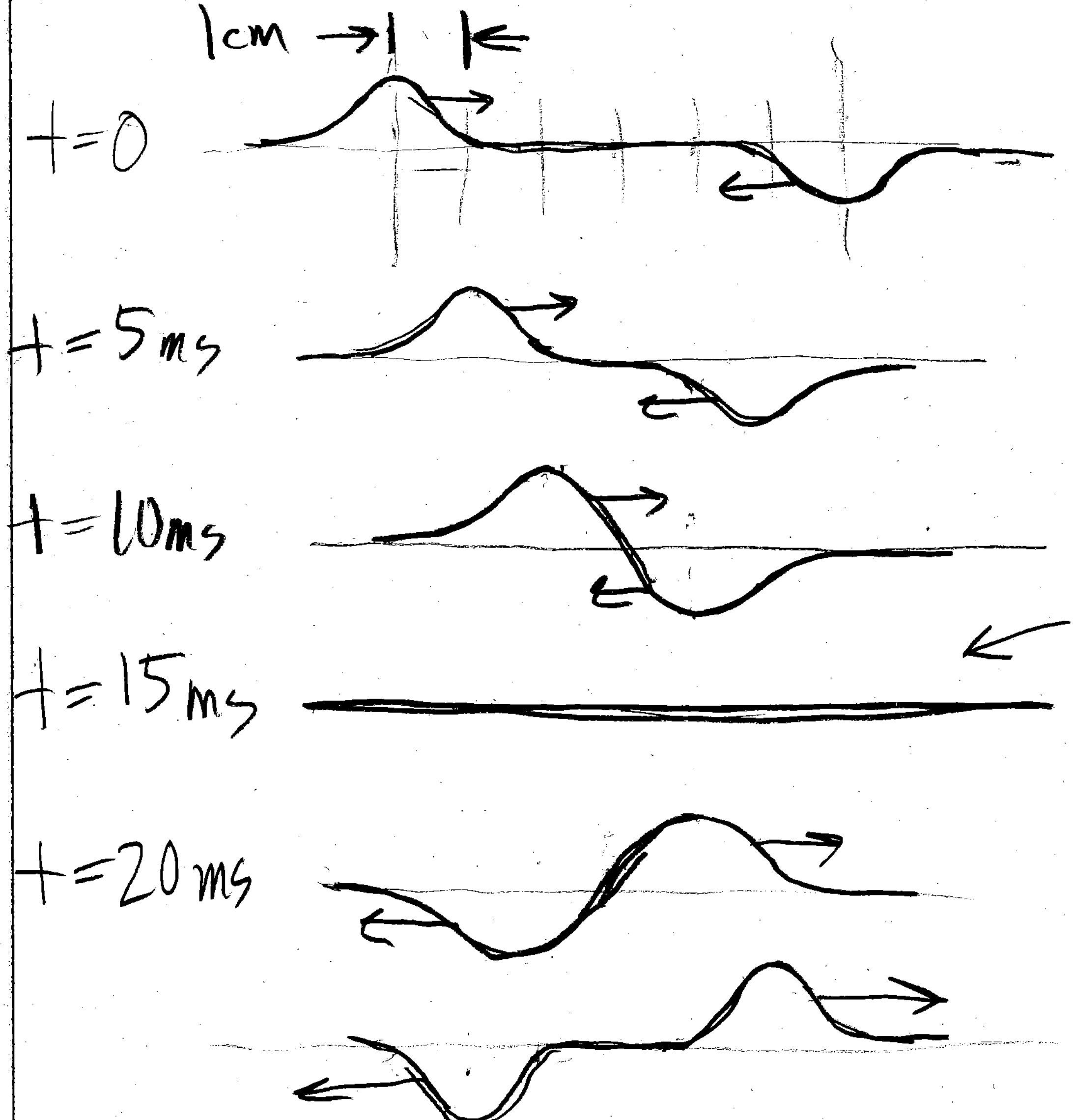
9) $\boxed{\text{PHK4 P 33}}$

$v = 2.0\ m/s = 200\ cm/s$

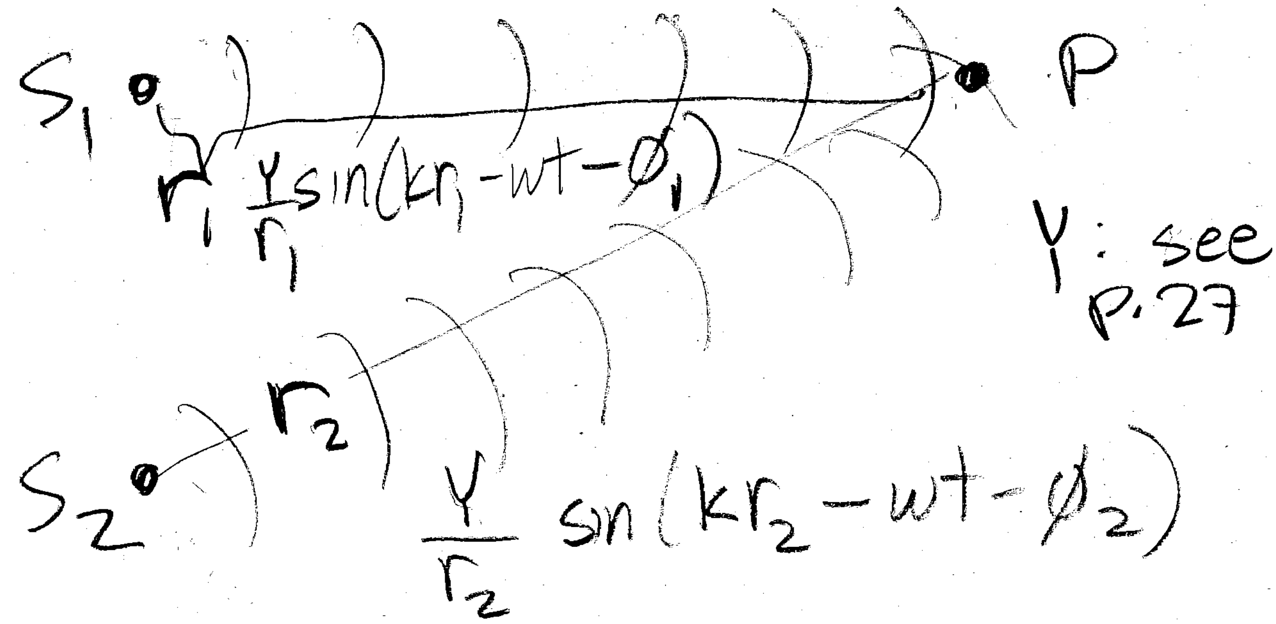
(a) $= 0.2\ cm/ms$

t (ms)	$\Delta x = vt$
5	1.0 cm
10	2.0 cm
15	3.0
20	4.0
25	5.0



(b) energy all kinetic

(10) RHK4 P36



(a) Superposition

$$y(P)=Y\left(\frac{1}{r_1}\sin(kr_1-\omega t-\phi_1)+\frac{1}{r_2}\sin(kr_2-\omega t-\phi_2)\right)$$

(i) $\phi_1=\phi_2$ "same phase"

(ii) set $t=0$ so $\phi_1=\phi_2=0$

$$r\equiv\frac{1}{2}(r_1+r_2)\qquad \Delta r\equiv r_1-r_2$$

then $r_1=r+\frac{1}{2}\Delta r$

$$r_2=r-\frac{1}{2}\Delta r$$

$$\frac{1}{r_1}=\frac{1}{r+\frac{1}{2}\Delta r}\cong\frac{1}{r}\left(1-\frac{1}{2}\frac{\Delta r}{r}\right)$$

$$\frac{1}{r_2} = \frac{1}{r - \frac{1}{2}\Delta r} \cong \frac{1}{r}\left(1 + \frac{1}{2}\frac{\Delta r}{r}\right)$$

so,

$$y(P) \cong \frac{Y}{r}\Big[\sin(kr_1 - \omega t) + \sin(kr_2 - \omega t)$$

$$- \frac{\Delta r}{2r}\left(\sin(kr_1 - \omega t) - \sin(kr_2 - \omega t)\right)\Big]$$

eq 35

$$\sin B \pm \sin C = 2 \sin \tfrac{1}{2}(B \pm C) \cos \tfrac{1}{2}(B \mp C)$$

$$\sin(kr_1 - \omega t) + \sin(kr_2 - \omega t)$$

$$= 2 \sin\left[\frac{k}{2}(r_1 + r_2) - \omega t\right]\left[\cos \frac{k}{2}(r_1 - r_2)\right]$$

$$\sin(kr_1 - \omega t) - \sin(kr_2 - \omega t)$$

$$= 2 \sin \frac{k}{2}(r_1 - r_2) \cos\left[\frac{k}{2}(r_1 + r_2) - \omega t\right]$$

so,

$$y(P) \cong \frac{2Y}{r}\Big[\cos\frac{k}{2}(r_1 - r_2) \sin\left[\frac{k}{2}(r_1 + r_2) - \omega t\right]$$

$$- \frac{\Delta r}{2r} \sin \frac{k}{r}(r_1 - r_2) \cos\left[\frac{k}{2}(r_1 + r_2) - \omega t\right]\Big]$$

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or

$$y(P) = \frac{2Y}{r}\left[\cos\frac{k\Delta r}{2}\sin[kr-\omega t] - \frac{1}{2}\frac{\Delta r}{r}\sin\frac{k\Delta r}{r} \times \cos(kr-\omega t)\right]$$

idea is: $\frac{\Delta r}{r}, \sin\frac{k\Delta r}{r}$ is <u>second order</u> in $\frac{\Delta r}{r}$ and negligible

$$y(P) = \underbrace{\left(\frac{2Y}{r}\cos\frac{k\Delta r}{2}\right)}_{Y_m}\sin(kr-\omega t)$$

(b) <u>Cancellation</u>: $\frac{k\Delta r}{2} = (\underset{\text{integer}}{n}+\frac{1}{2})\pi$

$$\frac{\cancel{2\pi}}{\lambda}\frac{\Delta r}{\cancel{2}} = (n+\tfrac{1}{2})\cancel{\pi}$$

$$\boxed{\Delta r = r_1 - r_2 = (n+\tfrac{1}{2})\lambda}$$

Reinforcement $\frac{k\Delta r}{2} = n\pi$

so $\boxed{\Delta r = r_1 - r_2 = n\lambda}$

(11) RHK4 P40

$\mu = 7.16\ g/m \quad F = 152N$

$L = 89.4\ cm$

(a) $v = \sqrt{\frac{F}{\mu}} = \sqrt{\frac{152\ \frac{kg \cdot m}{s^2}}{7.16 \cdot 10^{-3}\ kg/m}}$

$\boxed{v = 145\ m/s}$

(b) $\lambda = \frac{2}{3} L = \frac{2}{3} \cdot 0.894\ m$

$\boxed{\lambda = 0.596\ m}$

(c) $\nu \lambda = v$ so

$\boxed{\nu = \frac{v}{\lambda} = \frac{145\ m/s}{0.596\ m} = 244\ Hz}$

(12) RHK4 P48

$n = 1$, so $\lambda = 2L = 2 \cdot 15 = 0.30\ m$

$v = 250\ m/s$

(a) string $\lambda \nu = v$, $\nu = \frac{v}{\lambda} = \frac{250\ m/s}{0.30\ m}$

$\boxed{\nu = 833\ Hz}$

(b) air $\lambda_a \nu = v_a \Rightarrow \boxed{\lambda_a = \frac{v_a}{\nu} = \frac{348}{833} = 0.418\ m}$