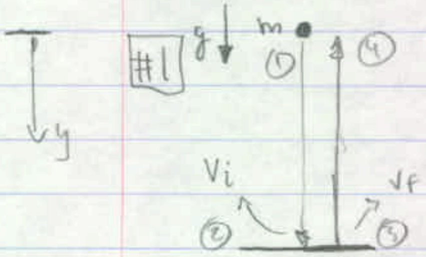
Physics 1C HW Problems

Ch. 12

#1



(A) $v_i = v_f$ (elastic)

$E_1 = mgh = \frac{1}{2}mv_i^2 = \frac{1}{2}mv_f^2 = mgh = E_4$

periodic motion $(h_1 = h_4)$

(B) $y(t) = \frac{1}{2}gt^2$ $(F_y = ma_y = +mg)$ ⇒

$y(T) = H = \frac{1}{2}gT^2$ ⇒ $T = \left(\frac{2H}{g}\right)^{\frac{1}{2}} = 0.9\text{ sec} = \frac{T}{2}$, T = period.

$T = 1.81\text{sec}$

(C) SHM $(F_y \neq -ky$ but $F_y = +mg)$, No

#3 $x(t) = 4\cos(\pi t + \pi)$ $[\, x(t) = A\cos(\omega t + \phi)\,]$

(A) $\omega = 2\pi f \Rightarrow f = \frac{\omega}{2\pi} = \frac{3\pi}{2\pi} = \frac{3}{2}\text{ Hz}$, $T = \frac{2}{3}\text{ sec}$

(B) $A = 4\text{ m}$

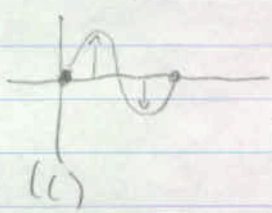
(C) $\phi = \pi$ rad!

(D) $x(t = 1/4\text{ sec}) = 2.83\text{ m}$

$\phi = 0$ ↙ #5 (A) $x(t) = (2\text{ cm})\sin(\omega t)$. $\phi = 0$; $\omega = \left(\frac{k}{m}\right)^{\frac{1}{2}} = 2\pi f = 2\pi\frac{3}{2}$

3 $A = 2\text{ cm}$

(B) $v(t) = -6\pi\cos(3\pi t)$; $v_{max} = v(0)$ [at $t = 0$]



$v_{max} = A\omega = 6\pi = 19\text{ cm/s}$; Next time is half a period, $t = \frac{T}{2} = \frac{1}{3}\text{ sec}$

(C)

(C) $a_{max} = A\omega^2 = 178\text{ cm/s}^2$ @ $t = \frac{3}{4}T$

(D) $t = 1$ second ; but $T = \frac{2}{3}\text{ sec}$ ⇒ $t = 1\text{sec} = T + \frac{1}{2}T$ (4A) + (2A)

thus, it takes $d = 2(2A) + 2A = 6A = 12\text{ cm}$

#11 $\omega = (k/m)^{\frac{1}{2}} = 4\ Hz = 2\pi f_0\ \ x(t)$

(A) $v_{max} = \boxed{A\omega = 40\ cm/sec}$, $a_{max} = A\omega^2 = \boxed{160\ cm/s^2}$

(B) $x(t_1) = 6\,cm = A\cos(\omega t_1)$, $t(x) = \frac{1}{\omega}\sin^{-1}\left(\frac{x}{A}\right)$.

$t_1 = \boxed{0.16\ sec = t(x_1 = 6\,cm)}$

(C) $t(0) = 0$, $t(8\,cm) = 0.2\ sec$

$t(8\,cm) - t(0) = \boxed{0.2\ sec}$

#13 $\frac{1}{2}mv^2 = \frac{1}{2}Kx^2 \Rightarrow v = x\left(\frac{k}{m}\right)^{\frac{1}{2}} = \boxed{2.2\ m/s}$

#15 (A) $E = \frac{1}{2}KA^2 = \text{constant} = \frac{1}{2}Kx_1^2 + \frac{1}{2}mv_1^2 = \frac{1}{2}KA^2$

$x_1 = \frac{A}{2}$; find v_1 : $\frac{1}{2}v_1^2 m = -\frac{1}{2}k\left(\frac{A}{2}\right)^2 + \frac{1}{2}kA^2 = \frac{1}{2}k\frac{3A^2}{4}$

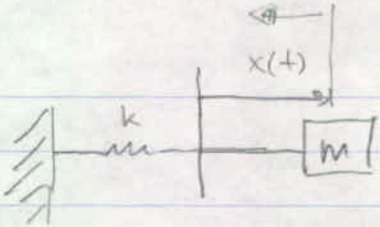
$v_1 = 30\ cm/sec$; find: $m = \left(k\frac{3A^2}{4}\right) \cdot \frac{1}{v_1^2} = \boxed{\frac{1}{2}\ kg}$

w/ $k = 6.5\ N/m$. (given)

(C) $T = 2\pi/\omega = 2\pi\left(\frac{m}{k}\right)^{\frac{1}{2}} = \boxed{1.8\ sec}$

(D) $a_{max} = A\omega^2 = \boxed{1.2\ m/s^2}$

#17



$x(t) = A\cos(\omega t + \phi)$

$\omega = \left(\frac{k}{m}\right)^{\frac{1}{2}} =$

(A)

$E = \frac{1}{2}kx^2(t) + \frac{1}{2}m\,v^2(t) = \frac{1}{2}kA^2 = \frac{1}{2}k\,(4\,cm)^2 = \boxed{28\ mJ}$

$x_1 = 1\,cm$ (B) $\frac{1}{2}kA^2 = \frac{1}{2}k\,x_1^2 + \frac{1}{2}m\,v_1^2 \Rightarrow v_1 = (k/m)^{\frac{1}{2}}(A^2 - x^2)^{\frac{1}{2}}$.

$v_1 = (k/m)^{\frac{1}{2}}((4\,cm)^2 - (1\,cm)^2)^{\frac{1}{2}} = \boxed{1\ m/s}$

(C) $K = \frac{1}{2}m v_1^2 = \boxed{12\,mJ}$

(D) $U = \frac{1}{2}k\,(3\,cm)^2 = \boxed{16\,mJ}$

#19 (A) $E = \frac{1}{2}kA^2$; $A' = 2A \Rightarrow E' = 4E$

(B) $V_{max} = \omega A \Rightarrow V'_{max} = 2V_{max}$

(C) $a = (-k/m)\,x \Rightarrow a' = 2A$

(D) $\omega = 2\pi f = 2\pi\frac{1}{T} \Rightarrow T = \frac{2\pi}{\omega} = 2\pi\left(\frac{m}{k}\right)^{\frac{1}{2}} \neq T(A)$

$\Rightarrow T' = T$, No change.

#21 $A = 3\,cm$; find x_1 @ $v_1 = \frac{1}{2}V_{max} = \frac{1}{2}(A\omega)$

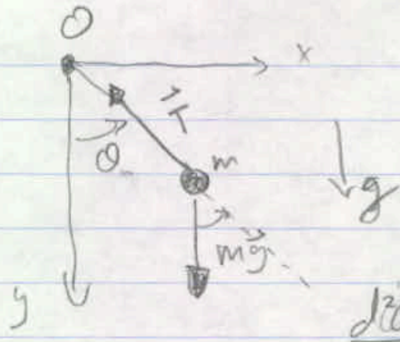
$E = \frac{1}{2}kx^2 + \frac{1}{2}mv^2 = \frac{1}{2}kA^2 \Rightarrow v^2 + \omega^2x^2 = \omega^2A^2$.

At (x_1, v_1): $\omega^2A^2 = \frac{1}{4}\omega^2A^2 + \omega^2x_1^2 \Rightarrow \omega^2x_1^2 = \frac{3}{4}\omega^2A^2 \Rightarrow$

$x_1 = \pm\frac{\sqrt{3}}{2}A = \boxed{\pm 2.6\,cm}$.

#23

#23



Γ = torque = $I \frac{d^2\theta}{dt^2} = -mgl\sin(\theta)$

$I \frac{d^2\theta}{dt^2} \simeq -mgl\theta$ [small angle]

$\frac{d^2\theta}{dt^2} = -\left(\frac{mgl}{I}\right)\theta \Rightarrow$

$\omega^2 = \frac{mgl}{I} = \frac{mgl}{\frac{1}{3}ml^2} = \boxed{g/l = \omega^2}$.

$\boxed{A = 15^\circ = \text{amplitude}}$

(A) $v_{max} = \omega A = (g/l)^{\frac{1}{2}}\left(15^\circ \cdot \frac{\pi}{180^\circ} \text{ rad}\right) = \boxed{0.82 \text{ m/s}}$

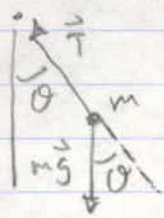
(B) $\alpha = \frac{d^2\theta}{dt^2}$; $a_{rad} = \alpha r \Rightarrow \alpha = \frac{a_{rad}}{l} = \frac{\omega^2 A}{l} = \boxed{2.5 \frac{rad}{s^2}}$

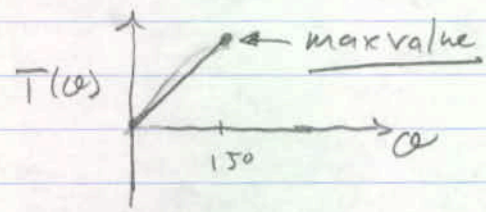
(radial acceleration)

(C) Tension = restoring force ; (15°)

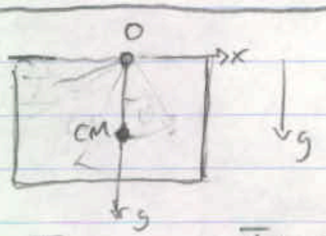
$T = mg\sin(\theta)$; $T_{max} = mg\sin(\theta_0) = \boxed{0.6 \text{ N}}$

max angle is the initial angle.





#27



$T = 2\pi\left(\frac{I}{mgd}\right)^{\frac{1}{2}}$ (from Book)

Solve for I: $I = T^2 \frac{mgd}{4\pi^2} = \boxed{0.94 \text{ kg} \cdot \text{m}^2}$

#31 solution: $x(t) = e^{-bt/2m}$;

$\theta_i = 15^\circ$ & $\theta_1 = 5.5^\circ \Rightarrow \frac{x(1000)}{x(0)} = e^{-\frac{b \cdot 1000}{2m}} = \frac{5.5^\circ}{15^\circ} \Rightarrow$

$\boxed{b/2m = 1 \times 10^{-3} \text{ sec}}$

Ch. 13

#1 $y(x,t)$; $x \to x - vt = x - 4.5t$; $y(x,t) = \dfrac{6}{(x-vt)^2+3}$.

#5 (A) $v = \frac{\omega}{k} = \frac{10}{3}$ m/s. ("$kx - \omega t + \phi$") $\Rightarrow$ $k = 3\pi$, $\omega = 10\pi$.

$v = \omega/k =$ 3.3 m/s & travelling to the right

(B) $y(0, 0.1m) =$ −5.8 cm   (C) $k = 2\pi/\lambda = 3\pi \Rightarrow \lambda = 0.67$ cm

$\omega = 2\pi f \Rightarrow f = 5$ Hz   (D) $v_{max} = A\omega = (10\pi)(0.35) =$ 11 m/s

#11 $y(x,t) = A\sin(kx + \omega t + \phi)$; $T = 25$ ms $= 2\pi/\omega$.

$v = \omega/k = 30$ m/s $\Rightarrow k = \omega/v = 2\pi/Tv$.

(A) At $t = 0$; $v_y(0,0) = -2$ m/s & $y(0,0) = 2$ cm

Also, $v_y(0,0) = -2 = -\omega A\cos(\phi)$ & $y(0,0) = 2 = A\sin(\phi)$

$(v_y(0,0))^2 \frac{1}{\omega} + y^2(0,0) = A^2 \Rightarrow A = 0.0215$ m

(B) $\dfrac{A\sin(\phi)}{B\cos(\phi)} = -2.51 = \tan(\phi) \Rightarrow \phi = 1.95$ rad

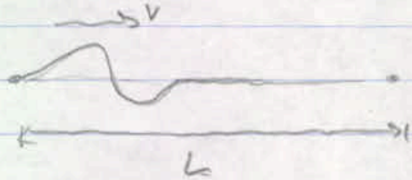
(C) $v_y^{max} = A\omega =$ 5.41 m/s

(D) $y(x,t) = (0.0215\text{m})\sin(kx + \omega t + \phi)$ with

$\omega = 80\pi$ & $k = 2\pi/Tv = 8.4$ m. & ϕ given above.

#12 (A) $\frac{\partial^2}{\partial x^2} y(x,t) = \frac{1}{c^2}\frac{\partial^2}{\partial t^2} y(x,t)$; just plug in & check.

#13

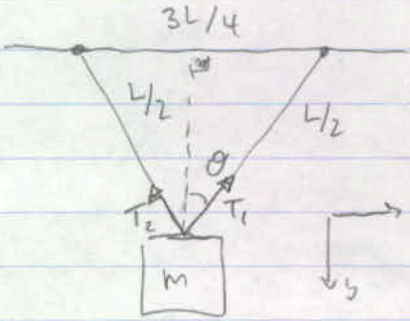


$v = (T/\mu)^{\frac{1}{2}}$ w/ $\mu = \frac{M}{L} = \frac{0.2\,kg}{4\,m}$

& $v = \frac{d_{total}}{T_{total}} = \frac{4(2L)}{0.8\,sec} = 40\,m/s \Rightarrow T = \mu v^2 = \boxed{80\,N}$.

#15 $\mu = T_1/v_1^2 = T_2/v_2^2 \Rightarrow T_2 = \left(\frac{v_2^2}{v_1^2}\right) T_1 = \boxed{13.5\,N}$.

#16



(A) • $T_1 \sin(\theta) = T_2 \sin(\theta) \Rightarrow \boxed{T_1 = T_2 = T}$

• $\boxed{2T\cos(\theta) = mg}$ w/

$\cos(\theta) = \frac{\frac{L}{2}}{\left(\frac{L^2}{4} + \frac{9}{16}L^2\right)^{\frac{1}{2}}} = \frac{\frac{1}{2}}{\left(\frac{1}{4}+\frac{9}{16}\right)^{\frac{1}{2}}}$

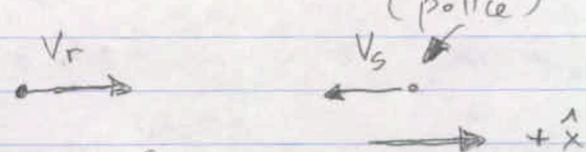
$\Rightarrow \boxed{\theta = 49°}$. $v = \left(\frac{T}{\mu}\right)^{\frac{1}{2}} = \left[\frac{\frac{1}{2}mg}{\mu\cos(\theta)}\right]^{\frac{1}{2}}$ w/ $\mu = 8\,g/m$.

(B) $v = 60\,m$, solve for m: $\boxed{m = 4\,kg}$.

#26 $f = 60\,kHz$, $v = 340\,m/s$; $v = \lambda f \Rightarrow$

$\boxed{\lambda = 5.7\,mm}$

#33 S



$f_s = 2500\,Hz$ = source frequency (police car)

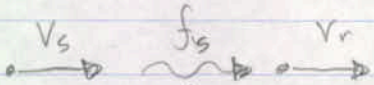
V_r = car (speed of sound)

V_s = police car $|V_r| = 25\ m/s$ & $c = 343\ m/s$

$|V_s| = 40\ m/s$

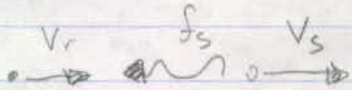
#33-cont. (A) approaching src: $f_r = f_s\left(\frac{c + V_r}{c - V_s}\right) = \boxed{3\ kHz}$
($V_r > 0$ & $V_s > 0$)

(B) receding src: $f_r = f_s\left(\frac{c - V_r}{c + V_s}\right) = \boxed{2\ kHz}$
($V_r < 0$ $V_s < 0$)

(C) 

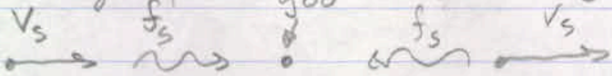
(police) ($V_r < 0$ & $V_s > 0$)

Behind: $f_r = \left(\frac{c - V_r}{c - V_s}\right) f_s = \boxed{2.6\ kHz}$

(D) 

($V_r > 0$ & $V_s < 0$) (police)

$f_r = f_s\left(\frac{c + V_r}{c + V_s}\right) = \boxed{2.4\ kHz}$

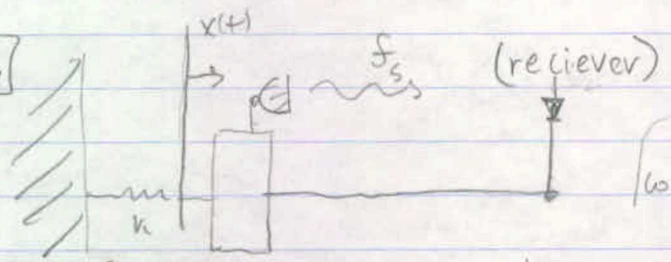
#35 

→ two cases: receding & approaching source w/ $V_r = 0$ [reciever].

Approaching Source: $f_r^{(1)} = f_s\left(\frac{c}{c - V_s}\right) = f_s\left(\frac{1}{1 - V_s/c}\right) = 560$

Receding Source: $f_r^{(2)} = f_s\left(\frac{1}{1 - (-V_s/c)}\right) = 480$

Solve for V_s w/ $c = 343\ m/s$: $\boxed{V_s = 26\ m/s}$

#36 

; $V_r = 0$ but $V_s(t) = A\cos(\omega t + \phi)$.

$\omega = \left(\frac{k}{m}\right)^{\frac{1}{2}}$ & $A = \frac{1}{2}m$.

Highest frequency occurs when $V_s \geq +A\omega = +V_s^{max} > 0$, when it is approaching.

$f_r = f_s\left(\frac{1}{1 - V_s/c}\right) = f_s\left(\frac{1}{1 - A\omega/c}\right)$

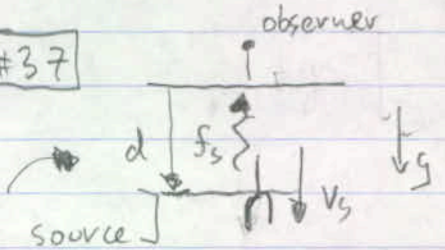
$$A\omega = V_{max} = 1\,m/s$$

$$f_s^{max} = 440\,Hz\left(\frac{343}{343 - A\omega}\right) = 441\,Hz$$

$$440\left(\frac{343}{343 + A\omega}\right) = f_s^{min} = 439\,Hz \text{ or when } V_s = -A\omega = -V_{max} < 0.$$

(receding source)

#37



[receding source]

$f_r = 485\,Hz$

$$v_s(t) = +gt + v_0^{\,0} = +gt \text{ [Free fall]}$$

We hear $f_r = 485\,Hz = f_s\left(\frac{c}{c + v_s(t)}\right)$ w/ $V_s = gt$

Solve for t_1 w/ $c = 340\,m/s$.

$$(f_r/f_s)^{-1} = \frac{c + gt}{c} \Rightarrow t_1 = 1.93\text{ sec}.$$

Now sound wave must return a distance d in time t_{return}:

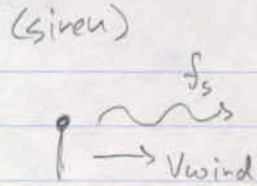
thus, solve for d: $t_{total} = t_1 + t_{return}$

w/ $d = \frac{1}{2} g t_1^2$ & so $t_{return} = \frac{d}{c}$, thus

$$d_{total} = \frac{1}{2} g\, t_{total} = \boxed{19.3\,m}.$$

#39

#39



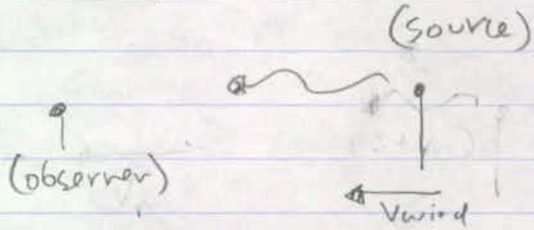
; wind increases/decreases

speed of sound : (A) upwards : $c' = c - V_{wind}$

$\lambda' = c'/f = 328/900 = \boxed{0.364 m}$

(B) downwind : $c' = c + V_{wind} \Rightarrow \boxed{\lambda' = 0.398 m}$

(C)



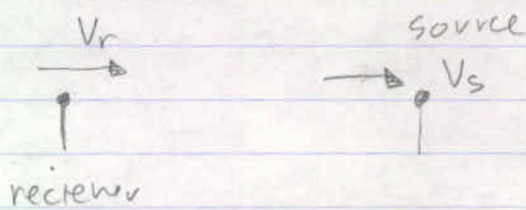
$V_r = 0$

$V_s = V_{wind} > 0$

approaching source

$$f' = 900\text{ Hz}\left(\frac{343}{343-15}\right) = 941\text{ Hz}$$

(D)



$V_r = +30$ m/s

$V_s = -15$ m/s

$$f' = 900\text{ Hz}\left(\frac{343+30}{343-(-15)}\right) = 938\text{ Hz}$$