17.1

$V_{light} = 3\times10^{8}\ m/s$

$V_{sound} = 343\ m/s$

Because the speed of light is so great, over small distances, it's arrival time is near instantaneous.

$$V_{sound}\,t = (343\ m/s)(16.2s)$$
$$= 5.56\ km$$
$$\approx 3.4\ miles$$

17.2 Hg

$B = 2.80\times10^{10}\ N/m^2$

$\rho = 13600\ kg/cm^3$

$$V^2 = \frac{B}{\rho}$$
$$\rightarrow V = 1.43\ km/s$$

17.17 Decibels for $I = 4\ \mu W/m^2 = 4\times10^{-6}\ W/m^2$

$$d\beta = 10\log_{10}\frac{I}{I_0} = 10\log_{10}\frac{4\times10^{-6}}{10^{-12}}$$
$$= 66\ d\beta$$

17.9

$V_{sound\ in\ human\ tissue} = 1500\ m/s$

a) ultrasound for heat $f = 2.4\ MHz$

$$f\lambda = V$$
$$(2.4\times10^{6}\ Hz)\lambda = 1500\ m/s$$
$$\lambda = 6.25\times10^{-4}\ m$$
$$= 0.625\ mm$$

b) $f = 1\ MHz$

$$f\lambda = V \longrightarrow \lambda = 1.5\times10^{-3}\ m = 1.5\ mm$$

$f = 20\ MHz$

$$f\lambda = V \longrightarrow \lambda = 7.5\times10^{-5}\ m = 75\ \mu m$$

17.16 Intensity = Power/Area

Area $= 5\times10^{-5}\ m^2$

a) Threshold of hearing

Intens $= 10^{-12}\ W/m^2$

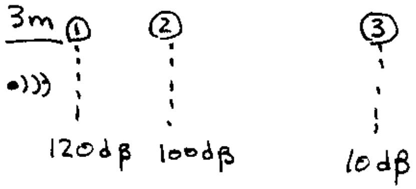
$$\text{Power} = (10^{-12}\ W/m^2)(5\times10^{-5}\ m^2)$$
$$= 5\times10^{-17}\ \text{Watts}$$

b) Threshold of pain

Intens $= 1\ W/m^2$

$$\text{Power} = (1\ W/m^2)(5\times10^{-5}\ m^2)$$
$$= 5\times10^{-5}\ \text{Watts}$$

17.29



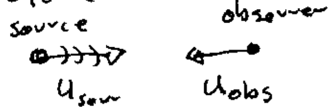

There are a couple of ways to approach this. One could just set up some equations, or one could reason it out. We'll do the 2nd way.

a) 120 dβ → 100 dβ means the sound intensity drops by 20 dβ or a factor of $10^2$ in intensity. Intensity falls as the square of distance. Therefore the distance is 10 times greater or 30 m

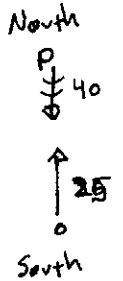
b) 120 dβ → 10 dβ means the sound intensity drops by 110 dβ or a factor of $10^{11}$ in intensity. Intensity falls as the square of distance. Therefore the distance is $\sqrt{10^{11}}$ times greater or $(3m)\sqrt{10^{11}} = 9.5 \times 10^5$ m

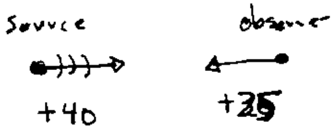
17.33 The formula is $f = f_0 \dfrac{V + u_{obs}}{V - u_{source}}$

which goes with the picture




a)

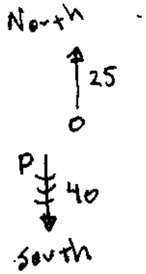


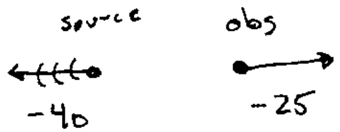




$$f = 2500 \frac{343+(25)}{343-(40)} = 2500 \frac{368}{303}$$

$$= 3036 \text{ Hz}$$

b)

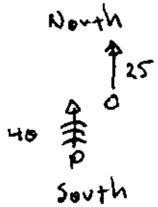


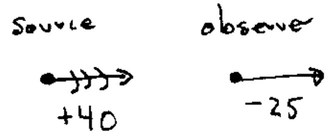




$$f = 2500 \frac{343+(-25)}{343-(-40)} = 2500 \frac{318}{383}$$

$$= 2076 \text{ Hz}$$

c)

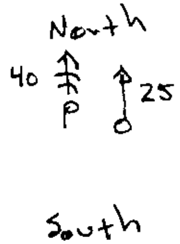


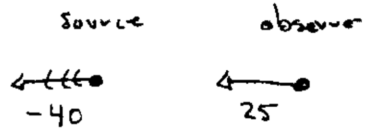




$$f = 2500 \frac{343+(-25)}{343-40} = 2500 \frac{318}{303}$$

$$= 2623 \text{ Hz}$$

d)

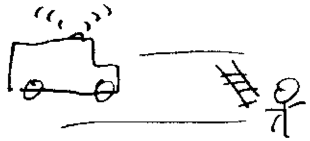



$$f = 2500 \frac{343+(25)}{343-(-40)} = 2500 \frac{368}{383}$$

$$= 2402 \text{ Hz}$$

17.35



$$f = f_0 \frac{V + u_{observer}}{V - u_{source}}$$

before

source observer

$u$

after

source observer

$-u$

560 Hz
$$f = f_0 \frac{V}{V - u_{source}}$$

480 Hz
$$f = f_0 \frac{V}{V - (-u_{source})}$$

$$= f_0 \frac{V}{V + u_{source}}$$

$$560 = f_0 \frac{343}{343 - u} \qquad 480 = f_0 \frac{343}{343 + u}$$

take ratio of equations

$$\frac{480}{560} = \frac{f_0 \frac{343}{343+u}}{f_0 \frac{343}{343-u}}$$

$$\frac{480}{560} = \frac{343-u}{343+u}$$

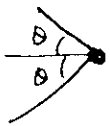
$$\frac{480}{560}\left[343+u\right] = 343 - u$$

$$294 + 0.857u = 343 - u$$

$$1.857u = 49$$

$$u = 26.4 \text{ m/s}$$

17.39

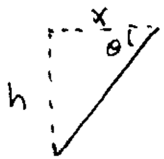



Mach angle

$$\sin\theta = \frac{V_{sound}}{V_{source}}$$

$$\sin\theta = \frac{1}{3}$$

$$\theta = 19.5^\circ$$




$h = 20{,}000\ m$

$$\tan\theta = \frac{h}{x}$$

$$\tan 19.5^\circ = \frac{20{,}000}{x}$$

$$x = 5.66 \times 10^{4} \text{ meters}$$