Homework #1

1) $\bar{y} = \frac{1}{N}\sum_i y_i = \frac{1}{8}\,40.471 = \boxed{5.059}$

$\sigma_y = \sqrt{\frac{1}{N-1}\sum_i (y_i - \bar{y})^2} = \boxed{0.037}$

$\sigma_{\bar{y}} = \frac{\sigma_y}{\sqrt{N}} = \boxed{0.013}$ $\left(\sigma_{\bar{y}} = \frac{\sigma_y}{\sqrt{N-1}} = 0.014 \text{ also accepted}\right)$

2) $m = \rho V = \rho\, l w h = 387.1\,g$

$\left(\frac{\sigma_m}{m}\right)^2 = \cancel{\left(\frac{\sigma_\rho}{\rho}\right)^2}^{\,0} + \left(\frac{\sigma_l}{l}\right)^2 + \left(\frac{\sigma_w}{w}\right)^2 + \left(\frac{\sigma_h}{h}\right)^2 = 3\cdot(0.01)^2$

$\frac{\sigma_m}{m} = \sqrt{3}\cdot 0.01 = \sqrt{3}\,\% = \boxed{1.73\,\%}$

$\sigma_m = \sqrt{3}\cdot 0.01 \cdot 387.1\,g = \boxed{6.7\,g}$

3) This is a systematic error. Making many measurements will not reduce this error.

If length is 1% too long, then $m_{meas} = \rho(1.01\,l)(1.01\,w)(1.01\,h)$

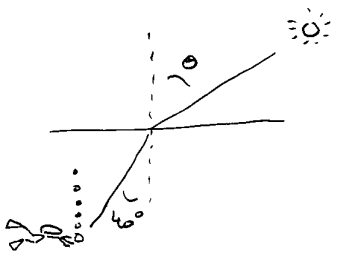
$= \rho\, lwh\,(1.01)^3$

$m_{meas} \approx 1.03\,\rho\, lwh = 1.03\, m_{true}$

This results in a 3% error.

4) The error in (3) is larger than in (2) because in (3) the errors are correlated.

5)



$n_{air} \sin\theta = n_{water} \sin 40$ ($n_{air} \approx 1$)

$\theta = \sin^{-1}(1.33 \sin 40) = \boxed{58.7^\circ}$

Horizon is at 90°. $n_{air} \sin 90 = 1.33 \sin\theta_{water}$

$\theta_{water} = \sin^{-1}\left(\frac{1}{1.33}\right) = \boxed{48.8^\circ}$

At angles larger than this, the diver sees light from underwater reflected off the water's surface.

6) $\psi(x,t) = Ae^{i(40x - 2000t)}$

$= Ae^{i(kx - \omega t)}$ $\quad k = 40\ m^{-1}$, $\omega = 2000\ Hz$

$v_{phase} = \frac{\omega}{k} = \boxed{50\ m/s}$

$\lambda = \frac{2\pi}{k} = \boxed{0.157\ m}$

$T = \frac{2\pi}{\omega} = \boxed{0.00314\ s}$