Solar cells (12 points)

Measure - note interesting variation with variable change
Analyse - linearize given expressions for proper graphing
Interpret – determine parameters/explain by drawing

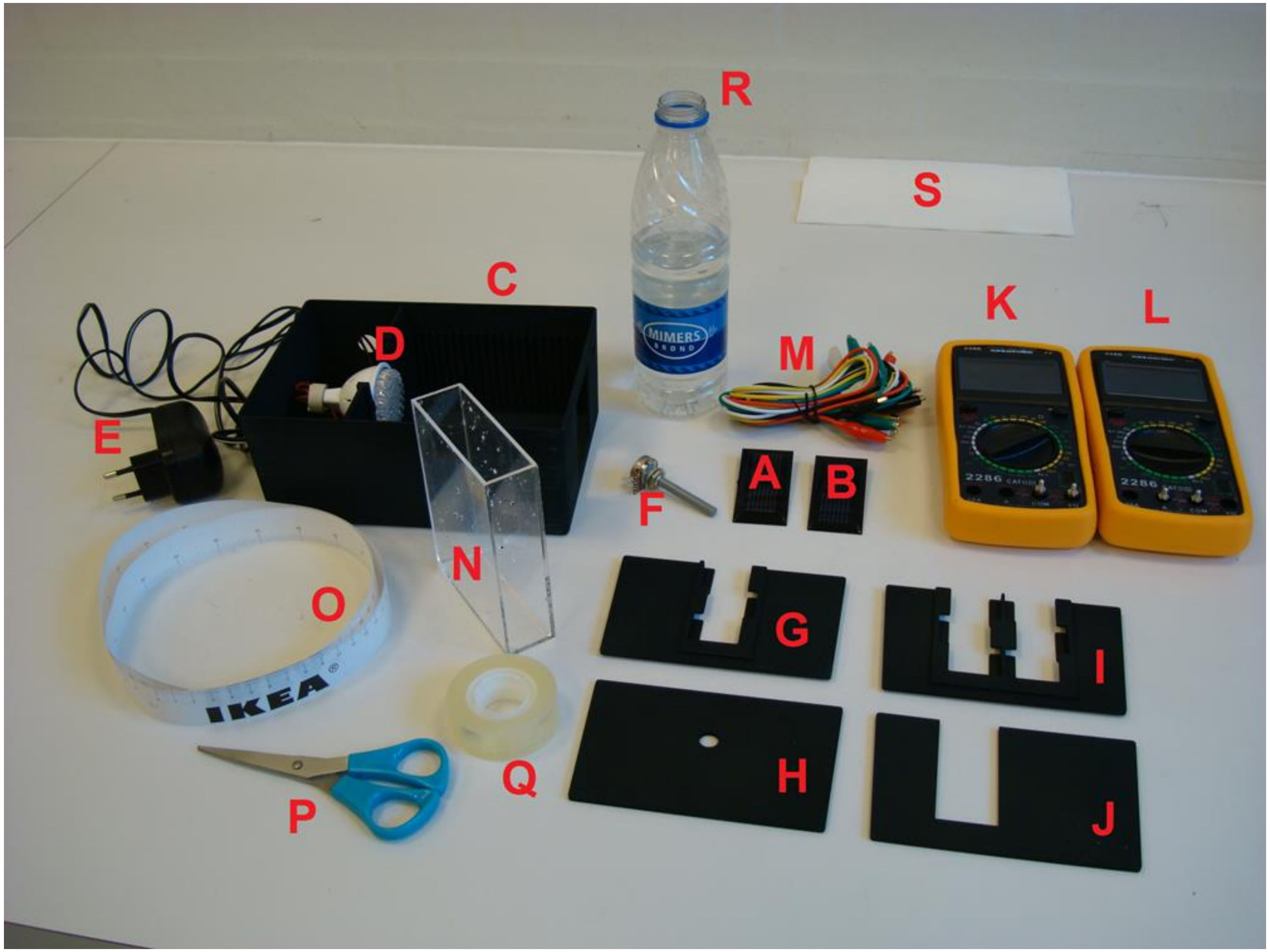
Base equipment: Solar cells, light source, load, meters

Phenomena:

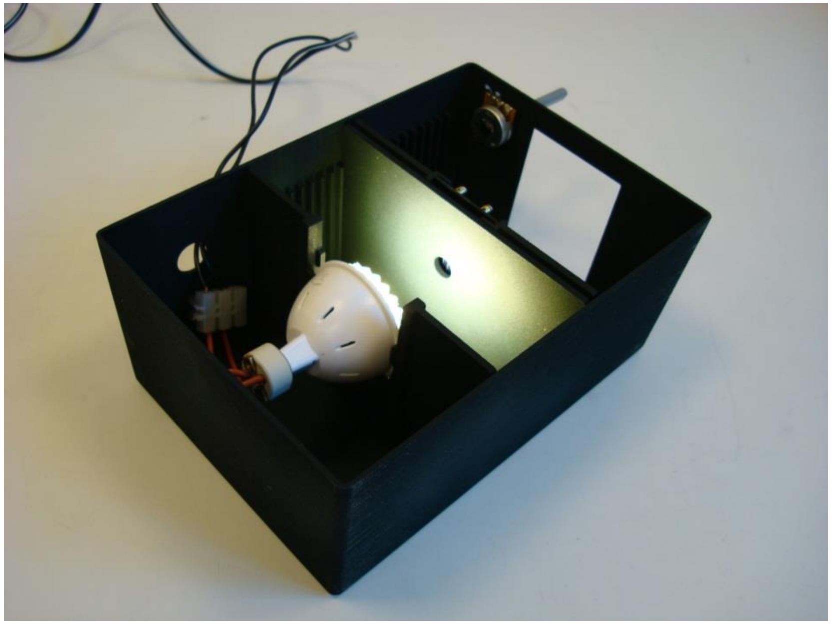
- Current dependence on distance to light source
- Current-voltage characteristic
- Power and coupling of solar cells
- Light beam intercepted by water column

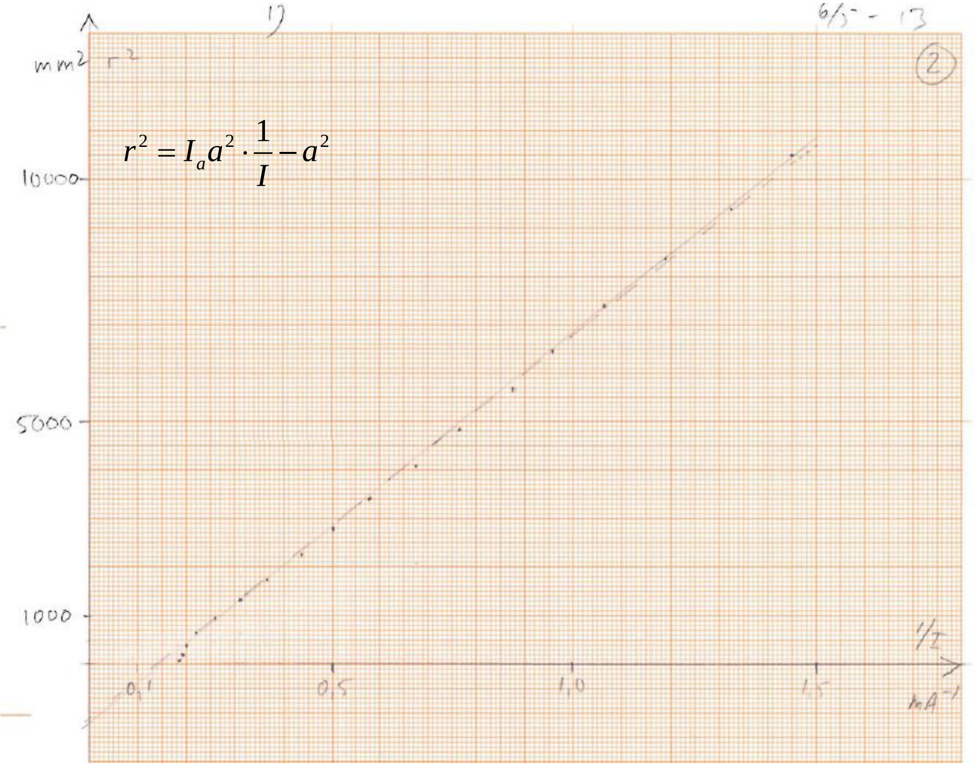
Solar cells

E2



Current dependence on distance to light source



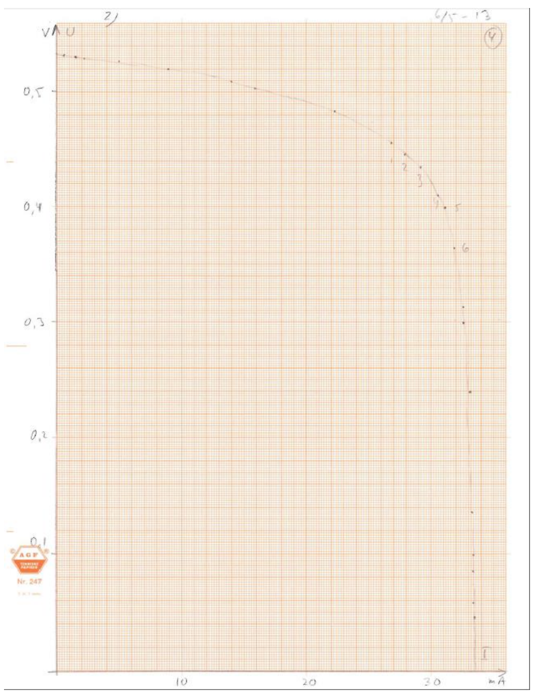


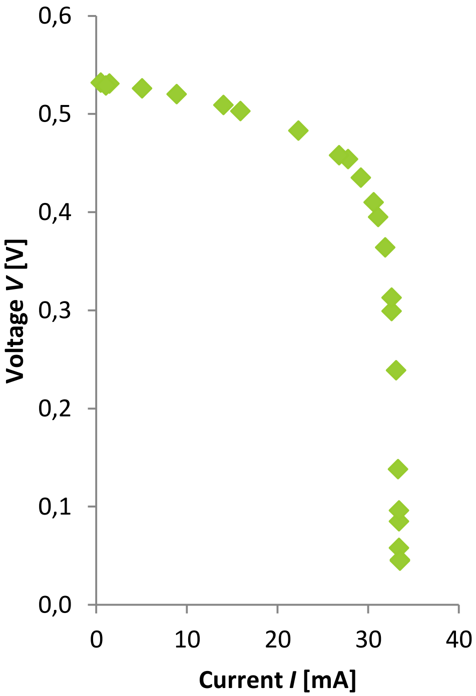
$$r^2 = I_a a^2 \cdot \frac{1}{I} - a^2$$

$$I(r) = \frac{I_a}{1 + \frac{r^2}{a^2}}$$

Current-voltage characteristic

$$I = I_{\max} - I_0\left(\exp\left(\frac{eU}{\eta k_B T}\right) - 1\right)$$

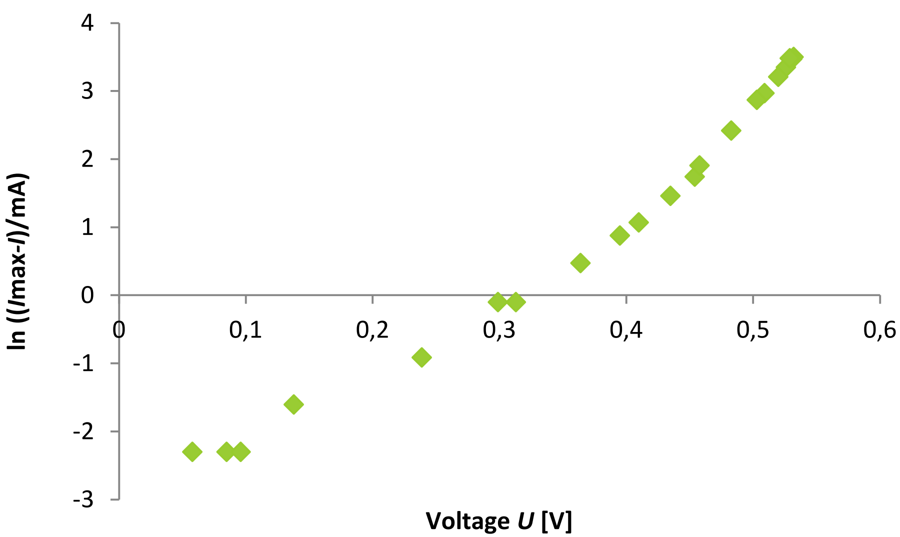


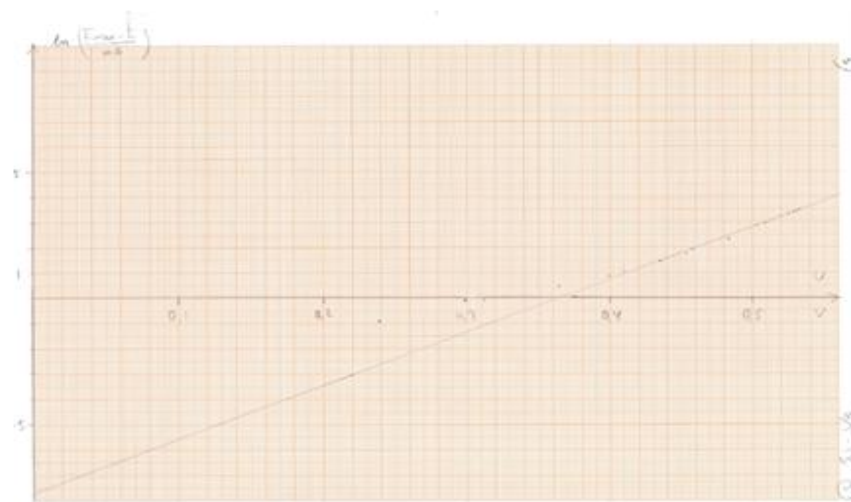


Current-voltage characteristic

$$I = I_{\max} - I_0\left(\exp\left(\frac{eU}{\eta k_{\mathrm{B}} T}\right) - 1\right)$$

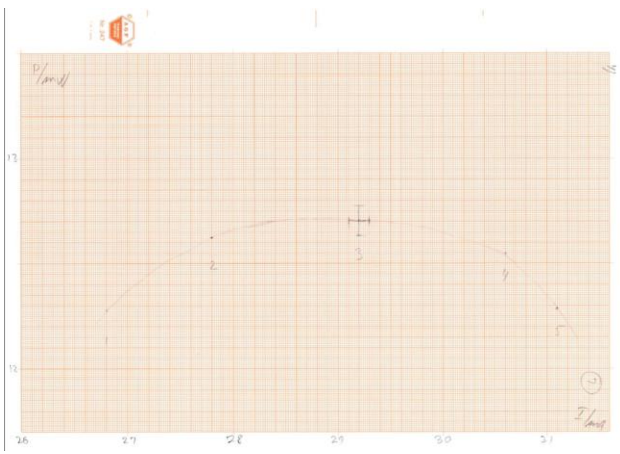
$$ln\left(\frac{I_{max} - I}{\mathrm{mA}}\right) = \frac{e}{\eta k_B T} U - ln\left(\frac{I_0}{\mathrm{mA}}\right)$$





Power, optimum load and comparison of solar cells

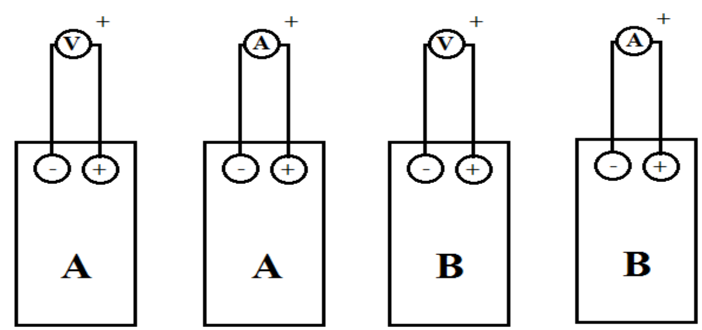
I	U	P	
mA	V	mW	
26.8	0.458	12.2744	1
27.8	0.454	12.6212	2
29.2	0.435	12.702	3
30.6	0.41	12.546	4
31.1	0.395	12.2845	5



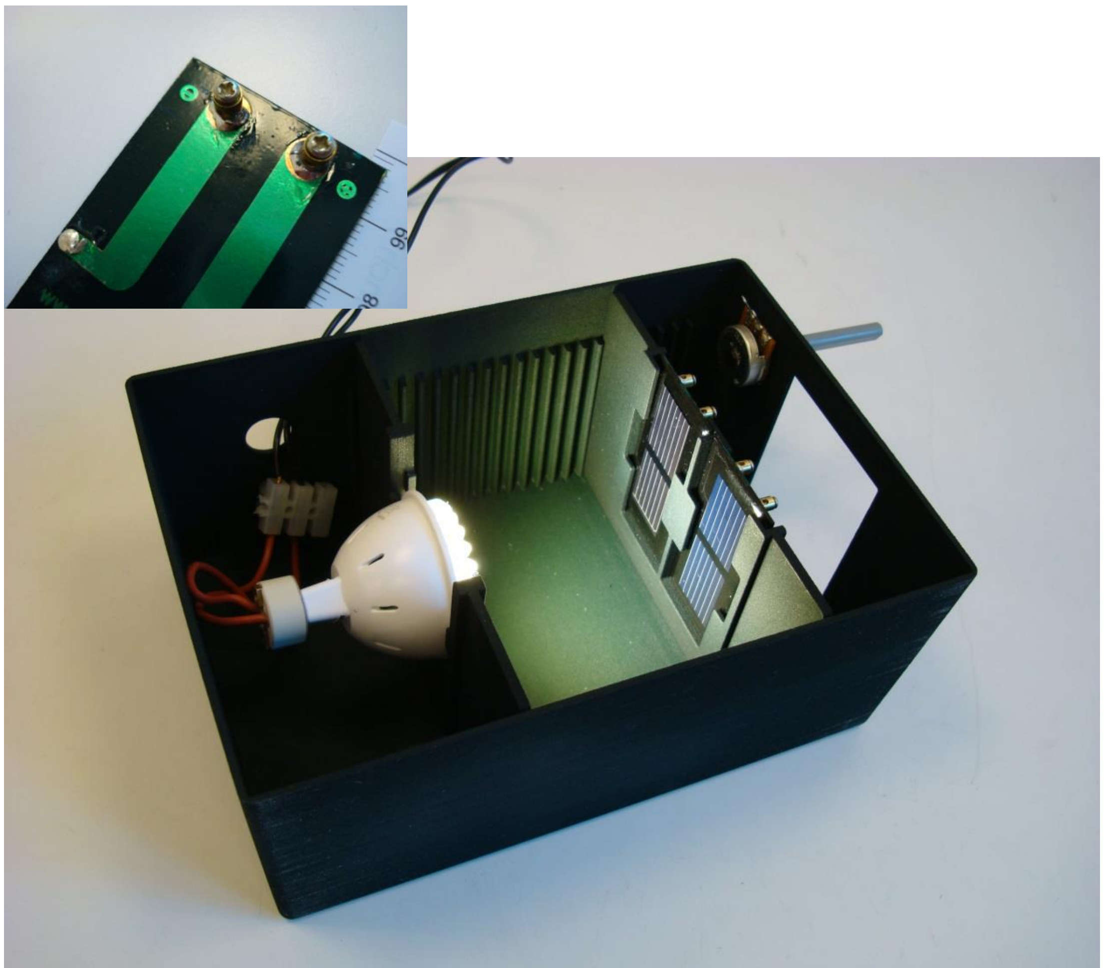
$$P_{\max} = (12.71 \pm 0.05)\,\mathrm{mW} \,@\, (28.8\ \pm 0.2)\,\mathrm{mA}$$

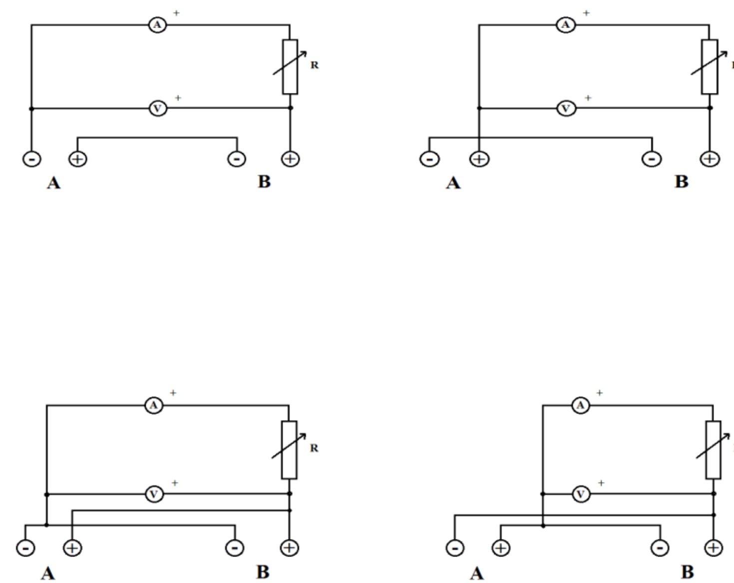
$$R_{\mathrm{opt}} = \frac{P_{\max}}{I_{\mathrm{opt}}^2} = \frac{12.71\mathrm{mW}}{(28.8\mathrm{mA})^2} = (15.3 \pm 0.3)\,\Omega$$

$$U_{\mathrm{opt}} = \frac{12.76\ \mathrm{mW}}{28.6\ \mathrm{mA}} = 0.446\ \mathrm{V}$$ ... and so forth

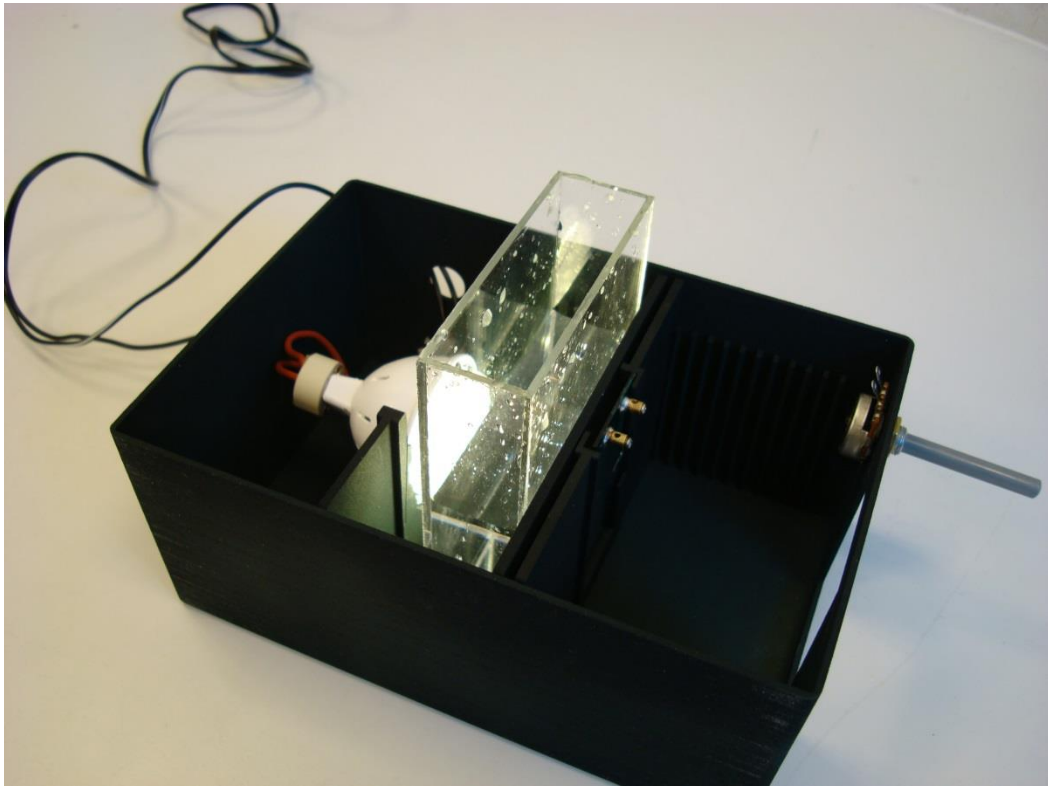


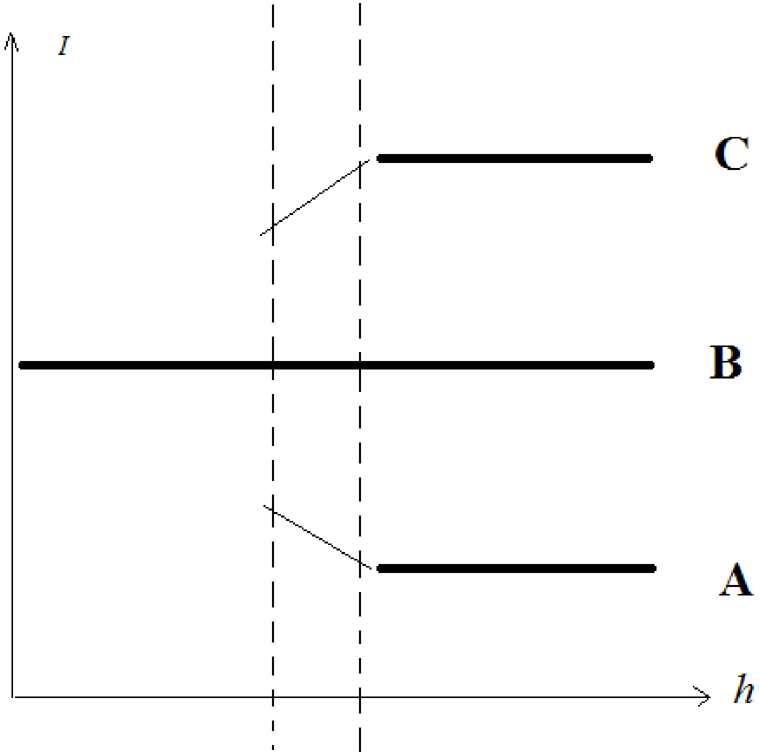
Coupling of solar cells



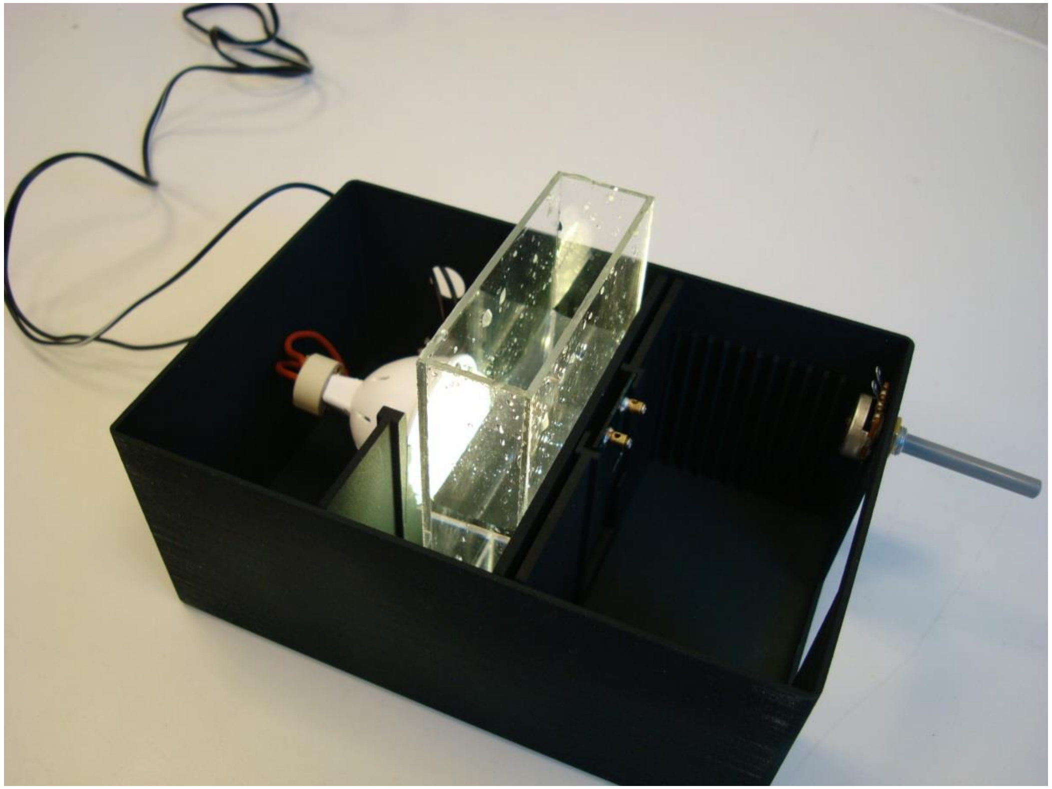


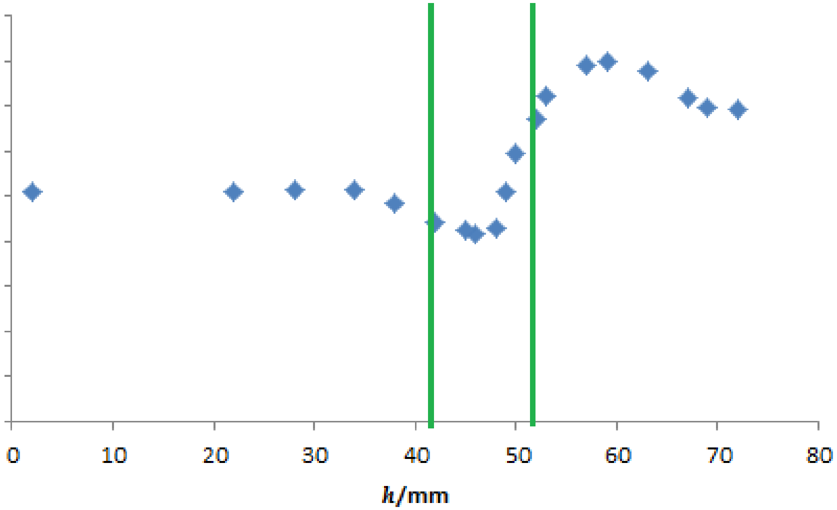
Light beam intercepted by water column



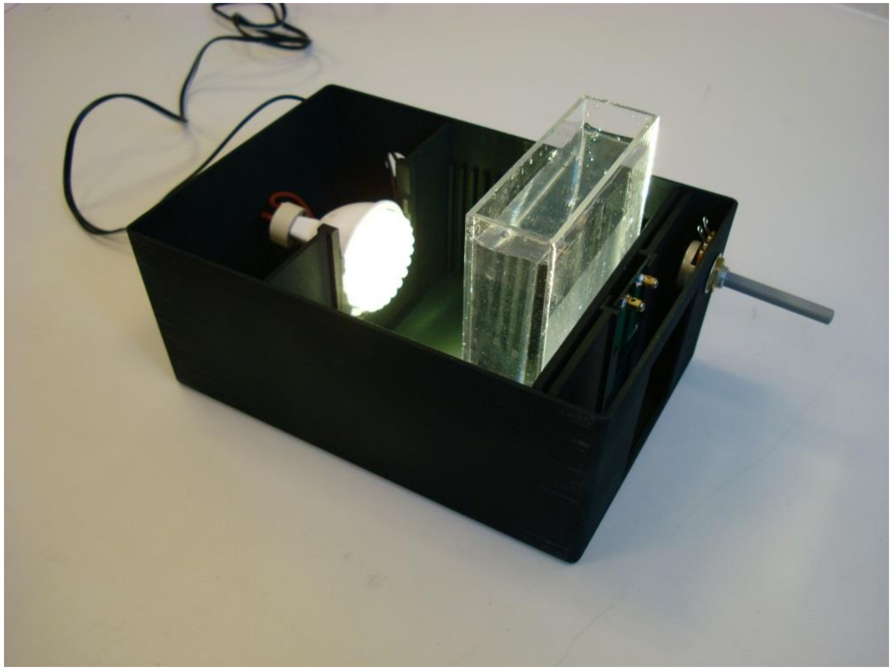


Light beam intercepted by water column





Light beam intercepted by water column

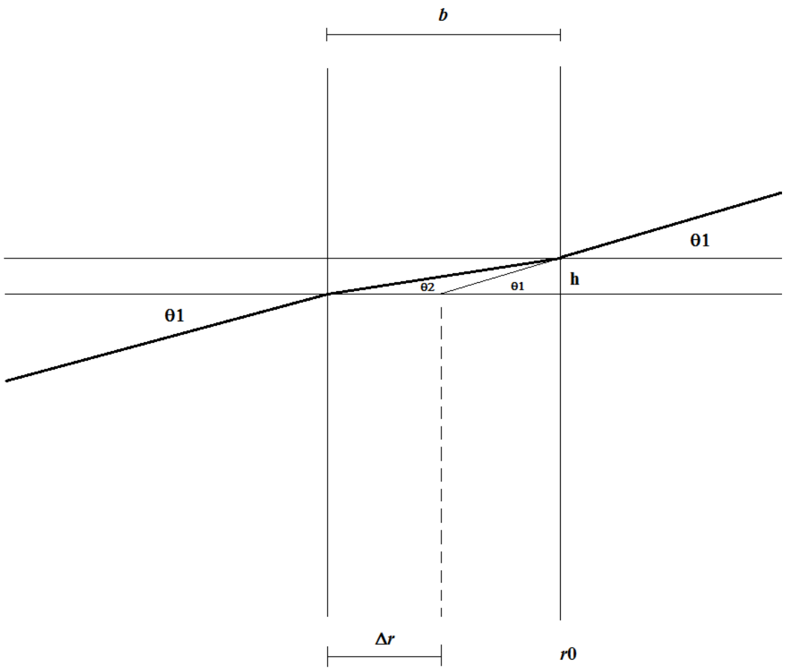


$r_0 = 102.0$ mm (slot 19)

$I_0 = 0.689$ mA No cuvette

$I_1 = 0.611$ mA Empty cuvette

Light beam intercepted by water column



$$r_0 = 102.0\ \text{mm (slot 19)};\ I_0 = 0.689\ \text{mA}$$

$I_1 = 0.611\ \text{mA}$ Empty cuvette

$I_2 = 0.683\ \text{mA}$ Filled cuvette!

$$\frac{1}{I_2} \cdot \frac{I_1}{I_0} = 1.29837\ \text{mA}^{-1} \sim {r_c}^2 = 9300\ \text{mm}^2 \sim r_c = 96.4\ \text{mm}$$

$$\frac{b}{b - \Delta r} = \frac{\tan\theta_1}{\tan\theta_2} \approx \frac{\sin\theta_1}{\sin\theta_2} = n_w$$