Problem set 1 (due on Friday April 27)

Problem 1 (2 pt).
To investigate the reproducibility of a method for the determination of selenium in foods, nine measurements were made on a single batch of brown rice with the following results (microgram/g): 0.07, 0.07, 0.08, 0.07, 0.07, 0.08, 0.08, 0.09, 0.08. Assuming that there is no systematic errors calculate: (1) mean (2) standard deviation (3) 95% and (4) 90% confidence interval for the concentration.

Mean = 0.077 microgram/kg. Standard deviation = 0.007 microgram/kg.
Degrees of freedom = 8
$t (95\%, 8) = 2.306$, $t (95\%, 8) = 1.860$.

confidence interval (95%) = 0.005
confidence interval (90%) = 0.004

Problem 2 (2 pts).
The results give the concentration of tin recovered from the same product after boiling for different times in an open vessel:

<table>
<thead>
<tr>
<th>Boiling time (min)</th>
<th>Tin found (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>57, 57, 55, 56, 55</td>
</tr>
<tr>
<td>75</td>
<td>51, 60, 48, 32, 46, 58, 56, 51</td>
</tr>
</tbody>
</table>

Test whether:
(1) the variability of the results is greater for the longer boiling time
(2) the means differ significantly

The means are 55.875 and 50.25 mg/kg and the standard deviations are 0.8345 and 8.828 mg/kg.

(1) $F_{7,7}$ (calculated) = 112. Critical value is 3.79. variability is significantly greater for longer boiling time.

(2) A pooled estimate of variance is not appropriate.

\[
t_{calculated} = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s_1^2/n_1 + s_2^2/n_2}} = 1.8
\]

degrees of freedom = \[\left\{ \frac{(s_1^2/n_1 + s_2^2/n_2)^2}{(s_1^2/n_1)^2/n_1 + (s_2^2/n_2)^2/n_2} - 2 \right\} = 7\]

Critical value (95\%, 7) = 2.365. The means do not differ significantly.
Problem 3 (2 pts)
Problem 2-11 from the textbook

2-11. (a) Electrical power $P = I \times V = 0.25 \text{ A} \times 3.0 \text{ V} = 0.75 \text{ W}$

Radiant power $\Phi = 0.01 \times P = 0.0075 \text{ W}$ or $7.5 \text{ mW}$

Photon flux $\Phi_p = 7.5 \times 10^{-3} \text{ J s}^{-1}/(hc/\lambda) \text{ J photon}^{-1}$

$$= \frac{7.5 \times 10^{-3} \times 550 \times 10^{-9}}{6.634 \times 10^{-34} \times 3.00 \times 10^8} \text{ photons s}^{-1}$$

$$\Phi_p = 2.07 \times 10^{16} \text{ photons s}^{-1}$$

(b) Since the photons are traveling at $3.00 \times 10^8 \text{ m s}^{-1}$ and are emitted into an area of $10 \text{ cm}^2 \ (10^{-3} \text{ m}^2)$, the volume covered each second is $3 \times 10^8 \text{ m s}^{-1} \times 10^{-3} \text{ m}^2 = 3 \times 10^5 \text{ m}^3 \text{ s}^{-1}$

The flux density is thus $rac{2.07 \times 10^{16} \text{ photons s}^{-1}}{3 \times 10^5 \text{ m}^3 \text{ s}^{-1}}$

$$= 6.9 \times 10^{10} \text{ photons m}^{-3}$$

Hence, there are $6.9 \times 10^{10}$ photons in a cubic meter.

(c) Photon emittance $M_p = \frac{7.5 \times 10^{-3} \text{ W}}{10 \text{ cm}^2} = 7.5 \times 10^{-4} \text{ W cm}^{-2}$

Problem 4 (2 pts)
Problem 3-6 from the textbook

3-6. $W' = b\lambda/W$

$$= (1.0 \text{ m} \times 488 \times 10^{-9} \text{ m})/100 \times 10^{-6} \text{ m} = 4.88 \times 10^{-3} \text{ m}$$

$$= 4.88 \text{ mm}$$