Problem 2 : Solution – Jumping Beads - a model for phase transitions and instabilities *(10 points)*

Part A. Critical driving amplitude (3.3 points)

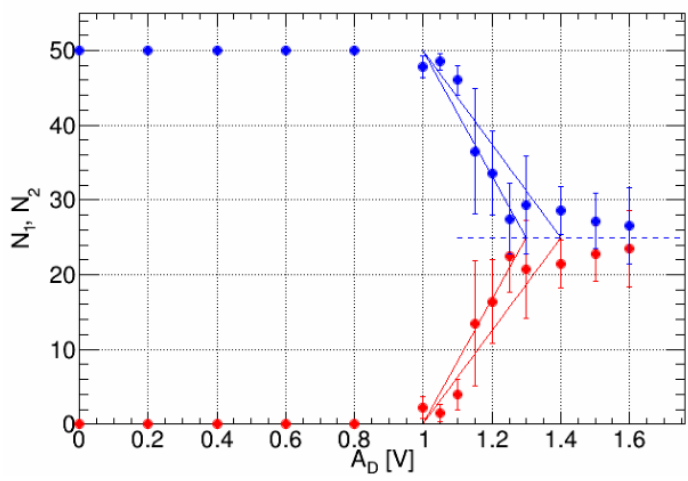
A1 (1.2 pts)

Total number of seeds: $N_0 = 50$.
Number of readings: $n = 6$.

A_D, [V]	N_1						$\bar{N}_1 = \frac{1}{n}\sum_{i=1}^{n} N_1^i$	$\bar{N}_2 = N_0 - \bar{N}_1$	$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(N_i - \bar{N})^2}{n-1}}$	SE $= \frac{\sigma}{\sqrt{n}}$
1.00	1	5	2	1	2	2	**2.2**	**47.8**	**1.5**	**0.6**
1.05	1	0	2	3	1	2	**1.5**	**48.5**	**1.1**	**0.5**
1.10	4	4	1	7	3	5	**4.0**	**46.0**	**2.0**	**0.8**
1.15	26	5	18	7	18	7	**13.5**	**36.5**	**8.4**	**3.4**
1.20	13	16	27	12	17	13	**16.4**	**33.7**	**5.6**	**2.3**
1.25	26	28	22	22	14	23	**22.5**	**27.5**	**4.8**	**2.0**
1.30	27	24	8	22	22	21	**20.7**	**29.3**	**6.6**	**2.7**
1.40	22	18	17	23	23	25	**21.4**	**28.7**	**3.2**	**1.3**
1.50	19	27	27	24	19	21	**22.8**	**27.2**	**3.7**	**1.5**
1.60	27	15	23	23	23	30	**23.5**	**26.5**	**5.1**	**2.1**

Plot the data in the graph A2.

A2 (1.1 pts)



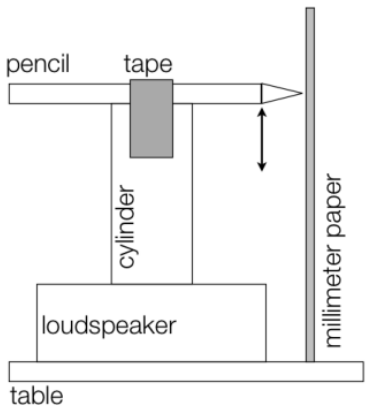
Error bars represent either standard deviation (σ) or standard error (SE).

A3 (1.0 pts)

$A_{D,\mathrm{crit}} = (1.25 \pm 0.05)\,\mathrm{V}$

Part B. Calibration (3.2 points)

B1 (0.5 pts)

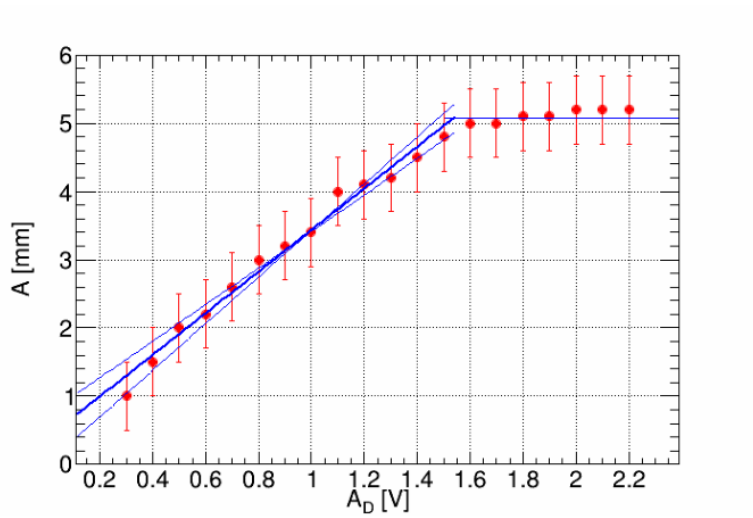


B2 (0.8 pts)

A_D [V]	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1
A [mm]	1.0	1.5	2.0	2.2	2.6	3.0	3.2	3.4	4.0	4.1	4.2	4.5	4.8	5.0	5.0	5.1	5.1	5.2	5.2

Instrumental error ±0.5 mm.

B3 (1.0 pts)



B4 (0.8 pts)

$A = k_0 + k_1 \times A_D$,
where:
$k_0 = 0.2\,[\text{mm}]$, $k_1 = 3.1\,[\text{mm/V}]$

B5 (0.1 pts)

$A_{\text{crit}} = (4.4 \pm 0.1)\,\text{mm}$

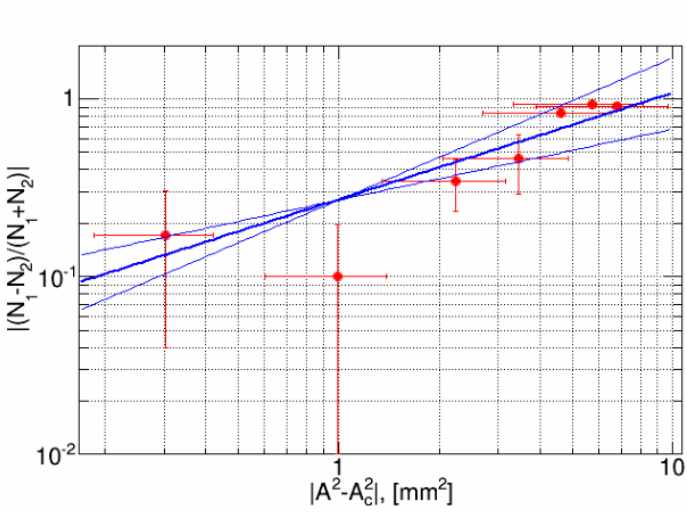
Part C. Critical exponent (3.5 points)

C1 (1.1 pts)

A_D, [V]	A, [mm]	$\left\lvert\frac{N_1-N_2}{N_1+N_2}\right\rvert$	$\lvert A^2 - A_0^2\rvert$
1.00	3.5	0.91	6.8
1.05	3.6	0.94	5.7
1.10	3.8	0.84	4.6
1.15	3.9	0.46	3.5
1.20	4.1	0.35	2.2
1.25	4.2	0.10	1.0
1.30	4.4	0.17	0.3
1.40	4.7	0.15	
1.50	5.0	0.09	
1.60	5.3	0.06	

Plot the data in the graph C2.

C2 (1.0 pts)



C3 (1.4 pts)

$y = a \cdot x^b$, where $x = |A^2 - A_0^2|$, $y = \left|\frac{N_1 - N_2}{N_1 + N_2}\right|$.

Critical exponent $b = 0.6 \pm 0.2$.