Elasticity of cantilever

Note : Please ensure the data and the answers must be expressed by scientific notation and SI unit. The unit of length should be meter.

Part A. Alignment of light path

A.1 (0.6 pt)
Please design a light path so that the laser spot hits the middle of the reflective area of the cantilever beam. Make sure the laser spot can stably appear near the origin of the PSD display screen and draw the relative position (coordinates and angles) of each component on the answer sheet.

A.2 (0.8 pt)
Since the cantilever beam will be disturbed when the device turned on, it may take some time to reach a stable state. After the instrument is turned on, the figure of the position of the light spot on the PSD and time will be displayed at the bottom right of the program. Please record the position d of the light spot on the PSD every 3 seconds under external disturbance after pressing the "Record" button. Please record at least 40 data points, and then press the "Stop" button to stop capturing data.

time (s)	position d (m)	time (s)	position d (m)	time (s)	position d (m)

A.3 (1.0 pt)
Please use the **stable segment** of the data obtained by **A.2** to find the reference value of measurement of this cantilever beam under the fluctuation of the experimental environment. ($\bar{d}$ **is the average value of** d).

d (m)	$\overline{d}$ (m)	$d-\overline{d}$ (m)	standard deviation

reference value of measurement (with standard deviation):

Note : For the convenience of the measurement in the following experiments, we assume the cantilever has reached its stable state under the influence of the environmental perturbation, i.e. the vibration of the optical components will not affect the measured value.

Note : Calculation of the standard deviation is not required in the following data analysis (Part B to Part D).

Part B. Deformation of cantilever beam and deduction of Young's modulus

B.1 (1.0 pt)
Please design the optical path when the external force is 0 N. Let the laser spot hit in the middle of the reflective area of the cantilever, and be sure about that the laser spot can stably appear near the center of the PSD display screen. Record the data on the table to obtain the measurement reference value d_0. The position of the light spot on the PSD at this time is set as the displacement $\Delta d = 0$. Then apply five different magnitudes of external forces on the cantilever, and record the experimental results in the table on the answer sheet.

F (N)	d (m)	$\overline{d} = d_0$ (m)

Then apply five different magnitudes of external forces on the cantilever, and record the experimental results in the table on the answer sheet.

F (N)	$d - d_0 = \Delta d$ (m)	$\overline{\Delta d}$ (m)
-		

F (N)	$d - d_0 = \Delta d$ (m)	$\overline{\Delta d}$ (m)
-		
-		

B.2 (1.0 pt)
Fill in the table. Make a plot by taking the magnitude of flexural deformation δ as the y-axis and $\overline{\Delta d}$ (the average of light spot displacement on the PSD) as the x-axis.

F (N)	δ (m)	$\overline{\Delta d}$ (m)

B.3 $(0.4\ \mathrm{pt})$
Please deduce the C_1 value from the optical leverage relationship $\delta = C_1\overline{\Delta d}$, as illustrated in Figure 3.

Part C. Double layer cantilever beam

C.1 (1.0 pt)
Please design a simple experiment diagram with light path. Let the laser beam show near the center of the reflected area. Record the data for room temperature, and find the measurement reference d_0, and used this reference as $\Delta d = 0$.

T (K)	d (m)	$\bar{d} = d_0$ (m)
300		

Then, increase the temperature to higher value, wait until the double layer beam stable then record the data. Try to do at least 5 different temperatures and record the data in the table of answer sheet.

T (K)	$d - d_0 = \Delta d$ (m)	$\overline{\Delta d}$ (m)
-		

T (K)	$d - d_0 = \Delta d$ (m)	$\overline{\Delta d}$ (m)
-		
-		

C.2 $(1.0\ \mathrm{pt})$
Fill in the table. Make a plot by taking the magnitude of flexural deformation δ as the y-axis and the temperature T as the x-axis. By data analysis, find the slope. You can use the correlation between δ and $\overline{\Delta d}$ in **B.3**.

T (K)	$\overline{\Delta d}$ (m)	δ (m)

C.3 (0.6 pt)
Use data from **C.2** to calculate the Young's modulus for the upper layer material.

Part D. Test of molecular-absorption-induced bending of a cantilever beam

D.1 (0.6 pt)
Design an optical path for Sample 0, so that the reflected laser spot locates at the center of the reflection zone, i.e. the laser spot appears stable in the origin of the PSD screen. Record the base value d_0 measured in the tables of the data sheet. The displacement Δd of the laser spot is set zero, $\Delta d = 0$ at this position. Then repeat the experiment with Sample 1. Record your answers on the tables of the data sheet. Note that Sample 1 has the highest coverage ratio (CR) in all samples.

	d (m)	$\bar{d} = d_0$ (m)
Sample 0		
-	$d - d_0 = \Delta d$ (m)	$\overline{\Delta d}$ (m)
Sample 1		

D.2 (0.6 pt)
Assume the function form of the magnitude of flexural deformation δ and coverage ratio (CR) can be expressed as : $\delta = C_2 \frac{CR}{EI^*} L^4$. Estimate C_2 based on your data obtained in **D.1**. You can use the correlation between δ and $\overline{\Delta d}$ in **B.3**.

D.3 (0.8 pt)
Use Sample 2 and Sample 3, same molecule but different CR. Measure the spot displacement Δd shown on PSD for both samples. Record your answers on the data sheet.

	$d - d_0 = \Delta d$ (m)	$\overline{\Delta d}$ (m)
Sample 2		
-	$d - d_0 = \Delta d$ (m)	$\overline{\Delta d}$ (m)
Sample 3		

D.4 (0.6 pt)
Please estimate CR of Sample 2 and Sample 3 (expressed in %).

Sample 2:

Sample 3: