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## Unit 8 - Week 6

### Course outline

How does an NPTEL online course work?

**Week 0**

**Week 1**

**Week 2**

**Week 3**

**Week 4**

**Week 5**

**Week 6**

**Quiz : Assignment 6 (assessment? name=67)**

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## Assignment 6

The due date for submitting this assignment has passed. **Due on 2020-03-25, 23:59 IST.**  
As per our records you have not submitted this assignment.

1) Consider a cantilever beam of length  $l$ , width  $b$ , and depth  $h$  made of a material with Young's **2 points** modulus  $Y$ . It has a fundamental natural frequency  $f_1$ . After scaling the width to  $\alpha b$  and depth to  $\beta h$ , its natural frequency changes to  $f_2$ . Calculate the ratio of these frequencies ( $f_1 : f_2$ ), if values of  $\alpha$  and  $\beta$  are  $10^{-3}$  and  $10^{-4}$  respectively. You can use, frequency,  $f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$  where,  $k$  is stiffness and  $m$  is effective mass of the beam. Again,  $m = cm_b$ , where,  $c$  is a constant and  $m_b$  is actual mass of the beam. You can also consider only transverse vibration

- $10^{-1}$
- $10^{-2}$
- $10^4$
- $10^3$

No, the answer is incorrect.  
Score: 0

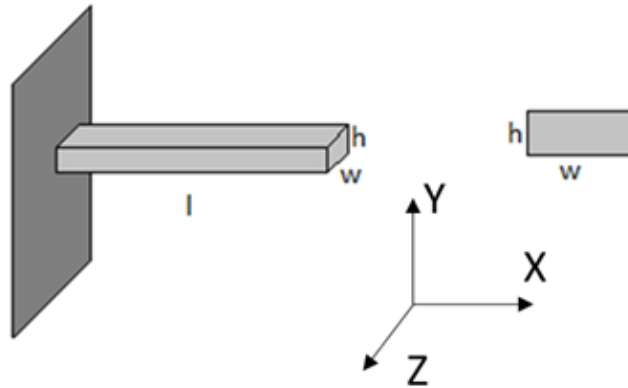
Accepted Answers:

$10^4$

2)

**2 points**

Consider a beam made of polysilicon with  $Y = 170$  GPa as shown in figure having length  $100 \mu\text{m}$ , width  $10 \mu\text{m}$  and height  $15 \mu\text{m}$ . A proof mass of  $50 \mu\text{g}$  is attached to its free end resulting in guided beam kind of motion. An acceleration is applied i) in Y-direction  $12 \text{ m/s}^2$  and ii) in Z-direction (i.e., perpendicular to the side face of the beam)  $15 \text{ m/s}^2$ . If the spring constant for a guided beam is  $\frac{12YI}{l^3}$ , what will be the magnitude of the deflection produced in Y and Z direction, respectively? All symbols have usual meaning.



- i)  $0.29 \mu\text{m}$ , ii)  $0.10 \mu\text{m}$
- i)  $0.10 \text{ nm}$ , ii)  $0.29 \text{ nm}$
- i)  $0.10 \mu\text{m}$ , ii)  $0.10 \mu\text{m}$
- i)  $0.10 \mu\text{m}$ , ii)  $0.23 \mu\text{m}$
- i)  $0.29 \mu\text{m}$ , ii)  $0.29 \mu\text{m}$
- i)  $0.15 \text{ nm}$ , ii)  $0.23 \text{ nm}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

i)  $0.10 \text{ nm}$ , ii)  $0.29 \text{ nm}$

3) 3. The electric energy density of a parallel plate capacitor (plate area A, gap between the plates d), if the electric field inside is E, is **1 point**

- $\frac{1}{2} \epsilon_0 E$
- $\frac{1}{2} \epsilon_0 E^2$
- $\frac{1}{4} \epsilon_0 E^2$
- $\frac{1}{2} \epsilon_0 E^3$

No, the answer is incorrect.

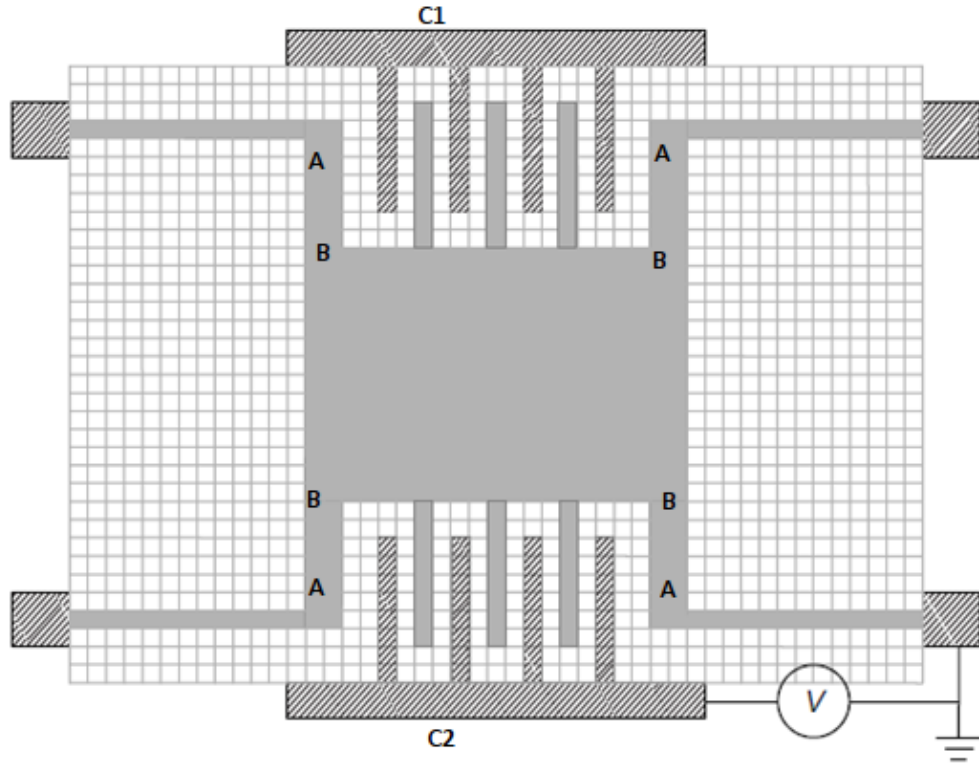
Score: 0

Accepted Answers:

$\frac{1}{2} \epsilon_0 E^2$

4)

The schematic of an in-plane accelerometer with a crab-leg suspension is shown below. Assume it is made of silicon whose Young's modulus is 169 GPa. The thickness everywhere is 25  $\mu\text{m}$ . Each square in grid has a size 5  $\mu\text{m} \times 5 \mu\text{m}$ . In order to perform a self-test, how much voltage needs to be applied to get a displacement of 5 nm? (Deflection of beams AB is negligible and the top fixed comp C1 is not connected to circuit)



Voltage = \_\_\_\_\_ V

No, the answer is incorrect.  
Score: 0

Accepted Answers:  
(Type: Range) 500,580

4 points

5) Which of the following processes will not avoid stiction?

1 point

- Fabricating a stiff cantilever
- Using wider beam instead of narrow beam
- Using methanol for washing instead of water
- Making narrow dimples at the tip of cantilever
- Super-critical drying

No, the answer is incorrect.  
Score: 0

Accepted Answers:  
Using wider beam instead of narrow beam

6) Thickness of a <100> silicon wafer is 410  $\mu\text{m}$ . A square window of 1000  $\mu\text{m}$  size is opened in the oxide on the front surface of the wafer with the mask edge aligned parallel to the <110> direction. The oxide on the back of the wafer is completely etched. This wafer is subjected to anisotropic etchant whose etch rate along the <100> direction is 50  $\mu\text{m}/\text{hour}$ . Due to this etching process for duration 4 hours, a

square diaphragm of thickness  $t \mu\text{m}$  and side  $x \mu\text{m}$  has been created. Determine the diaphragm thickness  $t$  in \_\_\_\_\_  $\mu\text{m}$

No, the answer is incorrect.  
 Score: 0  
 Accepted Answers:  
 (Type: Numeric) 10

2 points

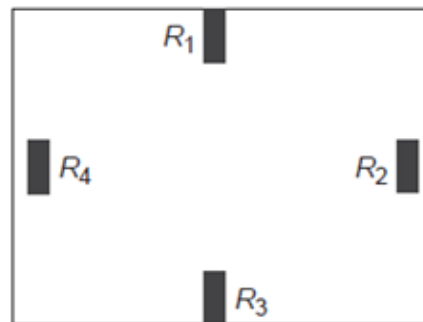
7) With the data given in question number 6, determine diaphragm side  $x$  in \_\_\_\_\_  $\mu\text{m}$

No, the answer is incorrect.  
 Score: 0  
 Accepted Answers:  
 (Type: Range) 700,730

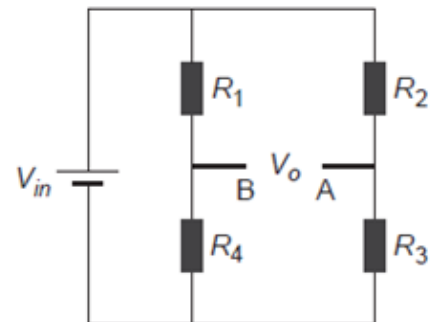
2 points

8)

Polycrystalline p-type piezo-resistors  $R_1, R_2, R_3,$  and  $R_4,$  each of them equal to  $R = 1\text{k}\Omega,$  are arranged as shown in figure below on oxide grown on a single-crystal membrane having lateral dimensions  $1\text{mm} \times 1\text{mm}$  and thickness  $= 10 \mu\text{m}.$  The polysilicon resistor has longitudinal gauge factor  $G_L = 30$  and the transverse gauge factor  $G_T$  is negligibly small ( $G_T = 0$ ). These resistors are connected in the form of a Wheatstone bridge as shown below. Assuming  $\nu = 0$  and  $Y = 150 \text{ GPa}$  for polysilicon, in this pressure sensor, what will be the sensitivity (in  $\text{mV/Bar}$ ) for an input voltage of  $V_{in} = 10 \text{ V}?$



(a)



(b)

\_\_\_\_\_  $\text{mV/Bar}$

No, the answer is incorrect.  
 Score: 0  
 Accepted Answers:  
 (Type: Range) 490,510

4 points

9) The maximum stress a Si pressure sensor can withstand is  $7 \text{ GPa}.$  Pressure is applied on a square membrane of side  $2a = 500 \mu\text{m}$  and thickness  $h = 10 \mu\text{m}.$  What should be the maximum operating range (in bar) of this pressure sensor for a safe application?

\_\_\_\_\_ bar

No, the answer is incorrect.  
Score: 0  
Accepted Answers:  
(Type: Range) 20,25

**2 points**