**ITU The Faculty of Mechanical Engg, CRN 12677 MAK422E Engg Design and CAD**

**Final Exam, Jan. 10, 2014 Time: 90 minutes, Instructor: Hikmet KOCABAS**

1. **(15)** What are the major disadvantages of Bezier curve representation?
2. **(15)** Check the validity of solid in figure 1 by using Euler-Poincare equation.
   F-E+V-L=2(B-G)

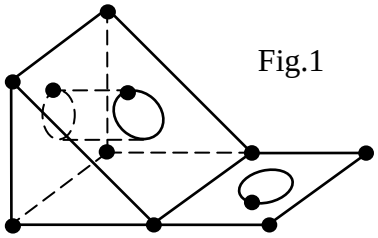


Fig.1

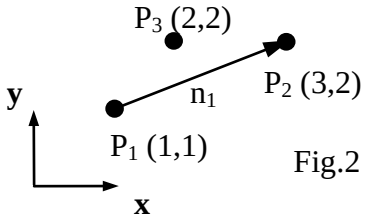
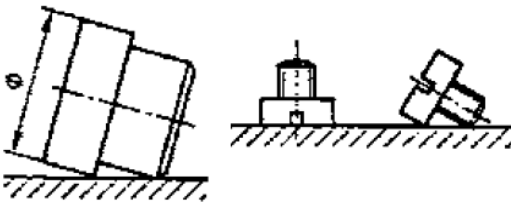


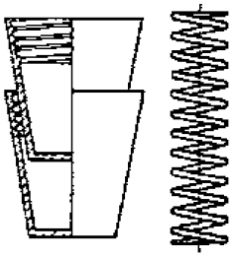

Fig.2

3. **(20)** Apply a mirror transformation with respect to the vector $\mathbf{n_1}$ defined with $\mathbf{P_1}$ **(1,1)**, $\mathbf{P_2}$ **(3,2)** on the point $\mathbf{P_3}$ **(2,2)**. Sketch the results.
4. **(15)** What is a Decision Matrix? Write a sample table.
5. **(15)** Write down the main principles of Design for Manufacture?
6. **(20)** How can you improve following designs in terms of DFA (handling and assembly)? Draw sketches and explain.

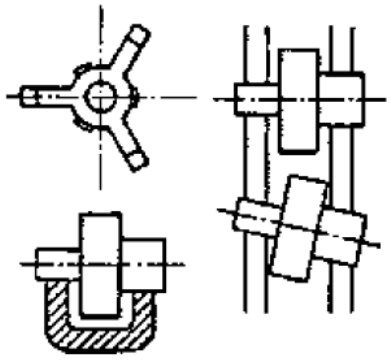
a)



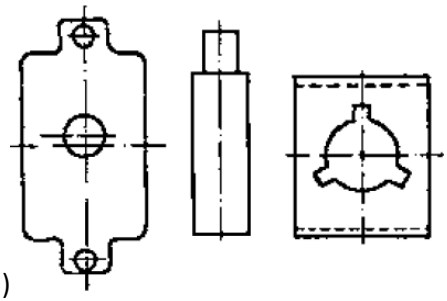
b)



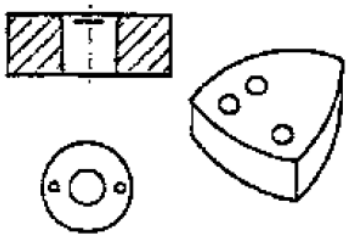
c)



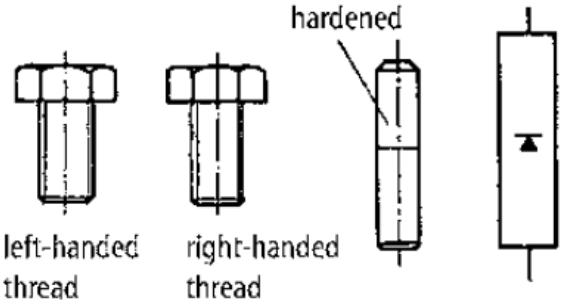
d)



e)



f)




Note: You may keep the question paper.

**ANSWERS OF QUESTIONS**

**1. (15)** What are the major disadvantages of Bezier curve representation?

A Bezier curve degree (n-1) is defined to the number of control points (n).
Moving a control point of the curve modifies the shape of the whole curve.

**2. (15)** Check the validity of solid in figure 1 by using Euler-Poincare equation:
F-E+V-L=2(B-G).

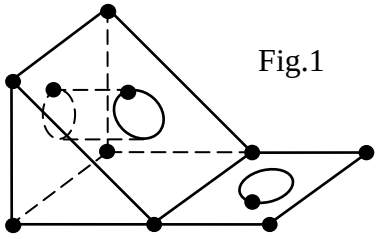
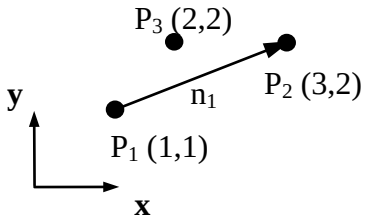


Fig.1

F-E+V-L=2(B-G) 7−16+11−3 = 2(1−2) = −1= −2 not valid

**3. (20)** Apply a mirror transformation with respect to the vector $\mathbf{n_1}$ defined with $\mathbf{P_1}$ **(1,1)**, $\mathbf{P_2}$ **(3,2)** on the point $\mathbf{P_3}$ **(2,2)**. Sketch the results.




$\mathbf{A} \cdot \mathbf{B} = |\mathbf{A}|.|\mathbf{B}|.\cos(\theta)$ $|\mathbf{A} \times \mathbf{n_1}| = |\mathbf{A}|.\mathbf{1}.\sin(\theta)$

$\mathbf{n_x} = (1,0,1)$ $\mathbf{n_1} = (\mathbf{P_2} - \mathbf{P_1}) / |\mathbf{P_2} - \mathbf{P_1}| = (2,1,0)/2.236 = (0.894; 0.447; 0)$

$\mathbf{n_1} \cdot \mathbf{n_x} = |\mathbf{1}|.|\mathbf{1}|.\cos(\theta)$ $\theta = \text{acos}(\mathbf{n_1} \cdot \mathbf{n_x}) = 0.464$ rad $= 26.565$ deg

$\mathbf{P_3'} = (\mathbf{T}+)\ \mathbf{R}(\theta)\ (\text{Mirror}_x)\ \mathbf{R}(-\theta)\ (\mathbf{T}-)\ \mathbf{P_3} = (2.4, 1.2, 1)$

$$P_1 := \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} \quad P_2 := \begin{pmatrix} 3 \\ 2 \\ 1 \end{pmatrix} \quad P_3 := \begin{pmatrix} 2 \\ 2 \\ 1 \end{pmatrix} \quad n_x := \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}$$

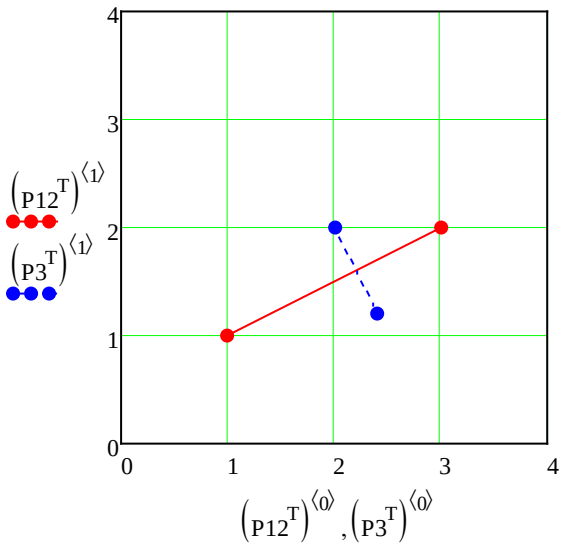
$$P_2 - P_1 = \begin{pmatrix} 2 \\ 1 \\ 0 \end{pmatrix} \qquad \left|P_2 - P_1\right| = 2.236$$

$$n_1 := \frac{P_2 - P_1}{\left|P_2 - P_1\right|} \qquad n_1 = \begin{pmatrix} 0.894 \\ 0.447 \\ 0 \end{pmatrix} \qquad \theta := \text{acos}\left(n_1 \cdot n_x\right) \qquad \theta = 0.464 \qquad \theta = 26.565\,\text{deg}$$

$$T0 := \begin{pmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{pmatrix} \quad T1 := \begin{pmatrix} 1 & 0 & -1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{pmatrix} \quad R_Z(\theta) := \begin{pmatrix} \cos(\theta) & -\sin(\theta) & 0 \\ \sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad R_Z(\theta) = \begin{pmatrix} 0.894 & -0.447 & 0 \\ 0.447 & 0.894 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$Mirr_X := \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \qquad T := T0 \cdot R_Z(\theta) \cdot Mirr_X \cdot R_Z(-\theta) \cdot T1 \qquad T = \begin{pmatrix} 0.6 & 0.8 & -0.4 \\ 0.8 & -0.6 & 0.8 \\ 0 & 0 & 1 \end{pmatrix}$$

$$P_3 = \begin{pmatrix} 2 \\ 2 \\ 1 \end{pmatrix} \quad P'_3 := T \cdot P_3 \quad P'_3 = \begin{pmatrix} 2.4 \\ 1.2 \\ 1 \end{pmatrix} \quad P12 := \begin{pmatrix} 1 & 3 \\ 1 & 2 \\ 1 & 1 \end{pmatrix} \quad P3 := \text{augment}(P_3, P'_3) \quad P3 = \begin{pmatrix} 2 & 2.4 \\ 2 & 1.2 \\ 1 & 1 \end{pmatrix}$$




**4. (15)** What is a Decision Matrix? Write a sample table.

Decision Matrix is used for grading the designs and selecting one of them to manufacture. It is a kind of feasibility table.

| Consumer Expectations (Features) | Product A | Product B |
|---|---|---|
| Controls | | |
| Handle | | |
| Balance | | |
| Power cord | | |
| Versatility | | |
| Overall sense of quality | | |
| Power | | |
| Tipover stability | | |
| Overall appearance | | |
| Total weight | | |
| Manufacturing:<br>Ease of assembly<br>Materials | | |

| | Ref. Concept | Concept 1 | Concept 2 | Concept 3 | Concept 4 |
|---|---|---|---|---|---|
| Criterion 1 | DATUM | + | - | - | S |
| Criterion 2 | | Same (S) | + | - | - |
| Criterion 3 | | + | - | S | - |
| Criterion 4 | | - | S | + | - |
| ∑ (+) | | 2 | 1 | 1 | 0 |
| ∑ (-) | | 1 | 2 | 2 | 3 |
| ∑ (S) | | 1 | 1 | 1 | 1 |

**5. (15)** Write down the main principles of Design for Manufacture.

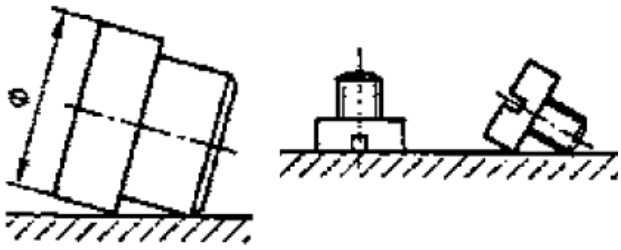
Answer 6. PRINCIPLES OF DFM

1. Reduce the total number of parts
2. Develop modular designs
3. Use standard components
4. Parts should be multi-functional
5. Parts should be multi-use
6. Parts should be designed for ease of fabrication
7. Avoid separate fasteners
8. Minimize the number of assembly directions.
10. Minimize handling

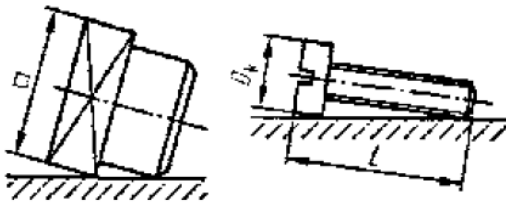
**6. (20)** How can you improve following design in terms of DFX (material, manufacturing process and assembly)? Draw sketches and explain.

Text book: Engineering Design, Springer (2007)Pahl_Beitz.pdf, pg.384, Fig.7.126, Embodiment Design

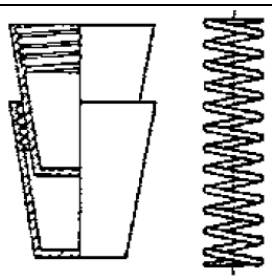
a).



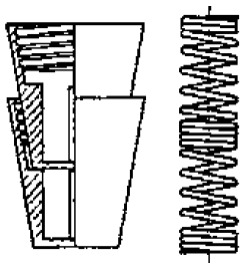
Prefer interface elements that have a stable position.



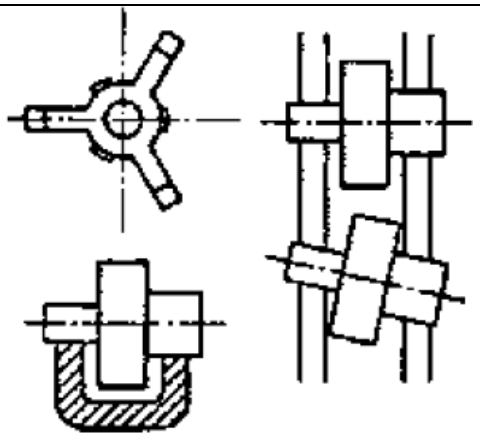
b).



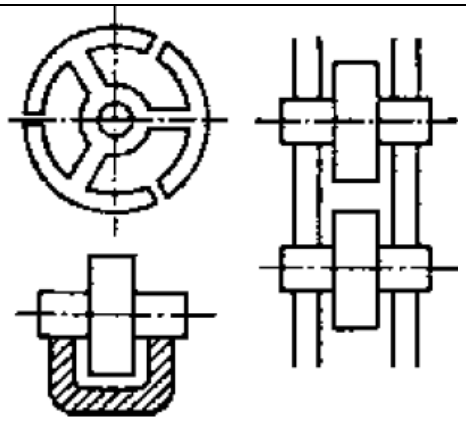
Avoid identical interface elements that can interlock.

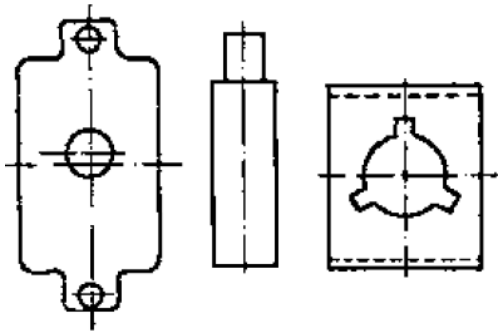
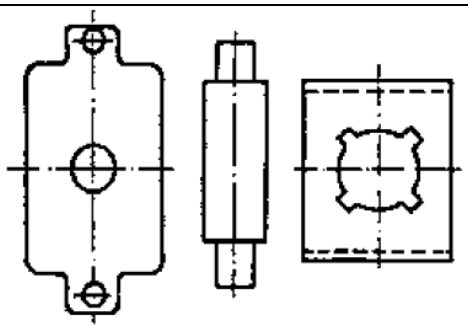
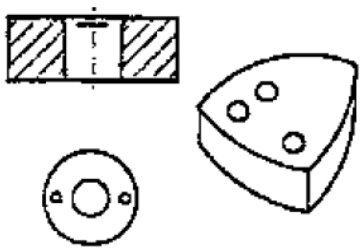
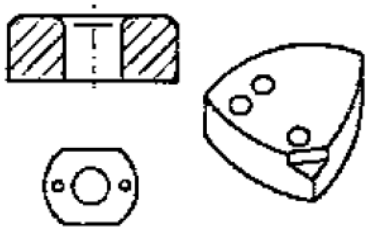
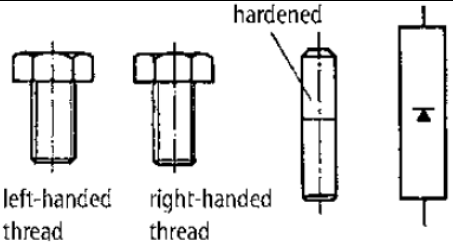
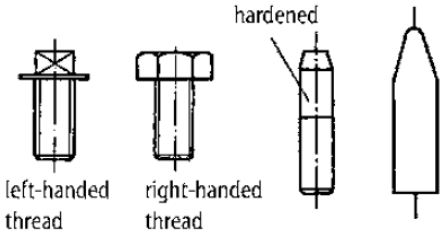


c).



Aim for interface elements that can roll.



| | | | |
|---|---|---|---|
| d).  | Aim for symmetric contours when a specific position is not required. |  | |
| e).  | Prefer identifiers on the outer contour. |  | |
| f).   | Aim for geometric identifiers. |   | |