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

Final Exam Extra, Jan. 22, 2014 Time: 90 minutes, Instructor: Hikmet KOCABAS

1. **(15)** How do you define a parametric surface S(u,v) such as a sweep?
2. **(15)** Check the validity of conveyor link BREP model in Fig.1 by using Euler-Poincare equation: F-E+V-L=2(B-G).

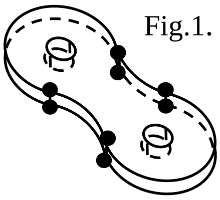


Fig.1.

Fig.1. Conveyor Link

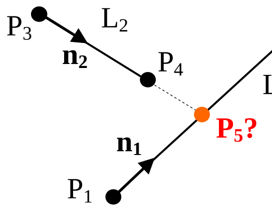
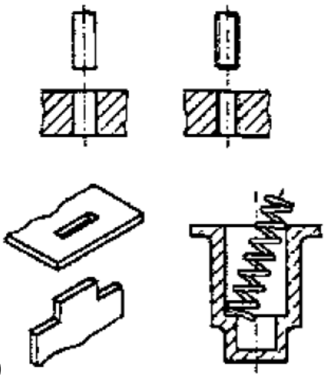
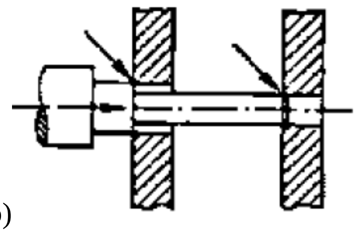


Fig.2.

3. **(20)** Extend L_2 to L_1 in figure 2 by using intersection point $\mathbf{P_5}$ of $\mathbf{L_1}$ and $\mathbf{L_2}$. Find the parameter **u** corresponding to this extention point P_5. $\mathbf{P_1}$ **(3,1)** , $\mathbf{P_2}$ **(7,6)** , $\mathbf{P_3}$ **(1,7)** , $\mathbf{P_4}$ **(3, 4)**.
   Use parametric line equations and vector algebra. $\mathbf{L_1 = P(u) \;=\; L_2 = P(v) \;=\; P_5}$
4. **(15)** What are the methods to generate concepts for a new design task?
5. **(15)** What are the advantages of engineering design techniques?
6. **(20)** How can you improve following designs in terms of DFA (handling and assembly)? Draw sketches and explain.



a)



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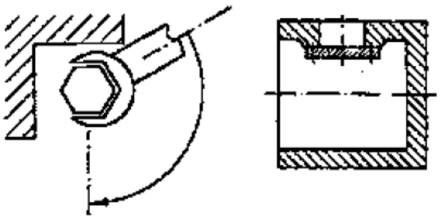

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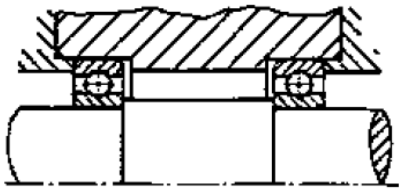
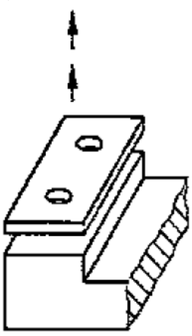
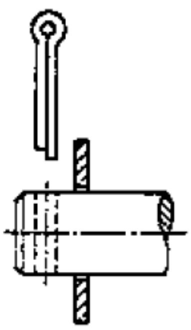


d) e)



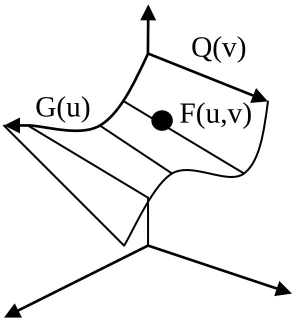


f)

Note: You may keep the question paper.

ANSWERS

1. **(15 points)** How to define a parametric surface S(u,v) such as a sweep.



Sweep surface: F(u , v) = G(u) + Q(v)

2. **(15 points)** Check the validity of conveyor link BREP model in Fig.2 by using Euler-Poincare equation: F-E+V-L=2(B-G).

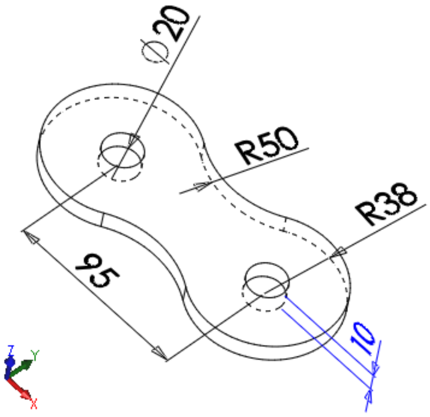


Fig.2. Conveyor Link

If the top and bottom surfaces are taken as two complete surfaces,

F-E+V-L=8-18+12-4=-2=2(B-G)=2(1-2)=-2 , so the BREP solid model is valid.

3. **(20 points)** Extend L_2 to L_1 in figure 2 by using intersection point $\mathbf{P_5}$ of $\mathbf{L_1}$ and $\mathbf{L_2}$. Find the parameter **u** corresponding to this extention point P_5. $\mathbf{P_1}$ **(3,1)** , $\mathbf{P_2}$ **(7,6)** , $\mathbf{P_3}$ **(1,7)** , $\mathbf{P_4}$ **(3, 4)**.

Use parametric line equations and vector algebra. $\mathbf{L_1 = P(u) \;\; = \;\; L_2 = P(v) \;\; = \;\; P_5}$

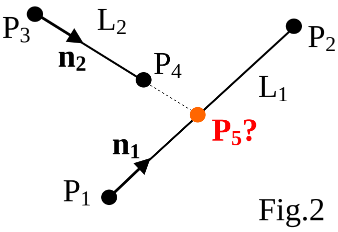


Fig.2

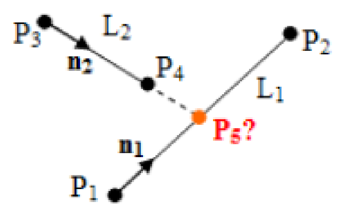
P_1 (3,1) , P_2 (7,6) , P_3 (1,7) , P_4 (3, 4).

Use vector algebra.

$n_1 = (P_2\ \ P_1) / |\ P_2\ \ P_1|$ $\qquad L_1 = P(u) = P_1 + u\,(P_2\ \ P_1)$

$L_1 = P(u) = P_1 + u\,(P_2\ \ P_1) = L_2 = P_3 + v\,(P_4\ \ P_3)$ $\quad \cdot\, n_5$

$$P_1 := \begin{pmatrix} 3 \\ 1 \\ 0 \end{pmatrix} \quad P_2 := \begin{pmatrix} 7 \\ 6 \\ 0 \end{pmatrix} \quad P_3 := \begin{pmatrix} 1 \\ 7 \\ 0 \end{pmatrix} \quad P_4 := \begin{pmatrix} 3 \\ 4 \\ 0 \end{pmatrix}$$



$$n_1 := \frac{P_2 - P_1}{|P_2 - P_1|} \qquad n_1 = \begin{pmatrix} 0.625 \\ 0.781 \\ 0 \end{pmatrix}$$

$$n_2 := \frac{P_4 - P_3}{|P_4 - P_3|} \qquad n_2 = \begin{pmatrix} 0.555 \\ -0.832 \\ 0 \end{pmatrix} \qquad n_3 := (n_1 \times n_2) \qquad n_3 = \begin{pmatrix} 0 \\ 0 \\ -0.953 \end{pmatrix}$$

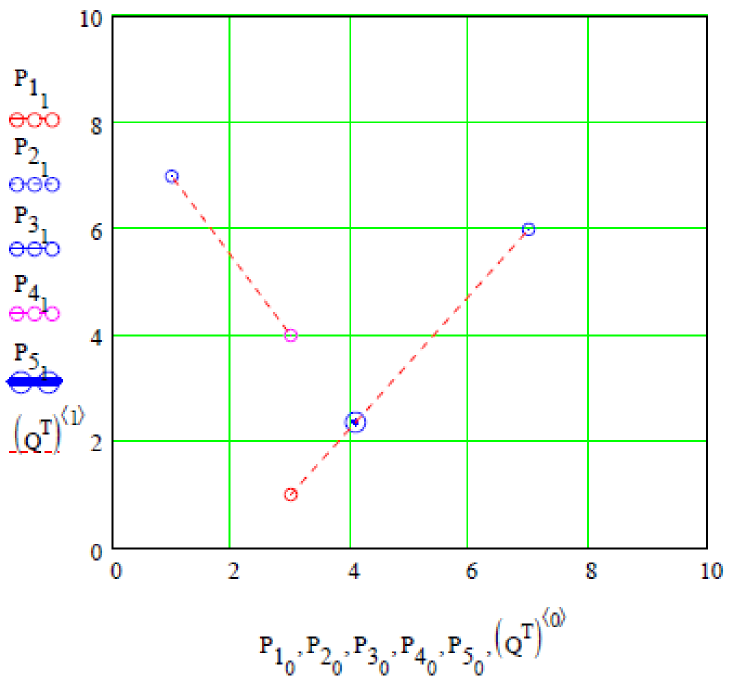
$$n_4 := (n_3 \times n_1) \qquad n_4 = \begin{pmatrix} 0.744 \\ -0.595 \\ 0 \end{pmatrix} \qquad n_5 := (n_2 \times n_3) \qquad n_5 = \begin{pmatrix} 0.793 \\ 0.529 \\ 0 \end{pmatrix}$$

$$P_1 + u\cdot(P_2 - P_1) = P_3 + v\cdot(P_4 - P_3) \qquad .\, \mathbf{n_5}$$

$$u := \frac{(P_3 - P_1)\cdot n_5}{(P_2 - P_1)\cdot n_5} \qquad u = 0.273 \qquad P_5 := P_1 + u\cdot(P_2 - P_1) \qquad P_5 = \begin{pmatrix} 4.091 \\ 2.364 \\ 0 \end{pmatrix}$$

$$P_1 + u\cdot(P_2 - P_1) = P_3 + v\cdot(P_4 - P_3) \qquad .\, \mathbf{n_4} \qquad v := \frac{(P_1 - P_3)\cdot n_4}{(P_4 - P_3)\cdot n_4} \qquad v = 1.545$$

for drawing purpose far point $\quad F := \begin{pmatrix} 10^{10} \\ 10^{10} \\ 0 \end{pmatrix} \qquad Q := \text{augment}(P_1, P_2, F, P_3, P_4, F, P_5)$



4. **(15 points)** What are the methods to generate concepts (invention) for a new design task?

Brain storming, inspiration, black box diagramming, literature search, patents

Configuration, Connection, Components, Copying, Decomposing, Form, Function, İnterface, Magnifying, Rearranging, Refine, Reversing, Substituting, Transition

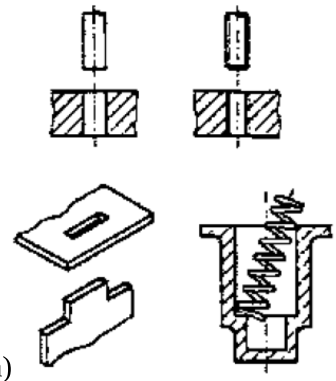
Inversion, Analogy, Fantasy, Technological advances, Brainstorming, Morphological analysis, Presentation

5. **(15 points)** What are the advantages of engineering design techniques?

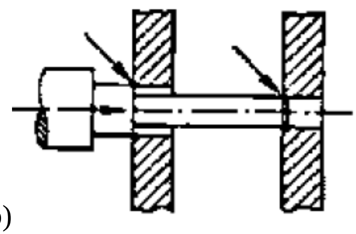
Answer: Advantages of these techniques are,

- shorter production times
- fewer production steps
- smaller parts inventory
- more standardized parts
- simpler designs that are more likely to be robust
- they can help when expertise is not available, or as a way to reexamine traditional design
- proven to be very successful over decades of application

6. **(20 points)** How can you improve following design in terms of DFX (Assembly)? Draw sketches and explain.



a)



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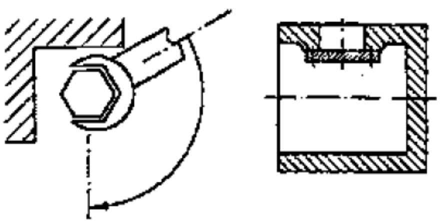

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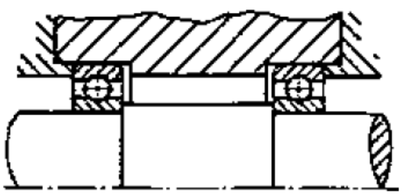
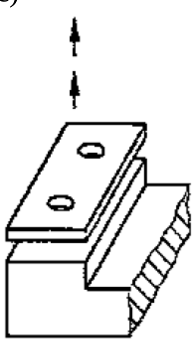
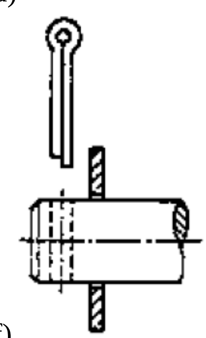


d) e)

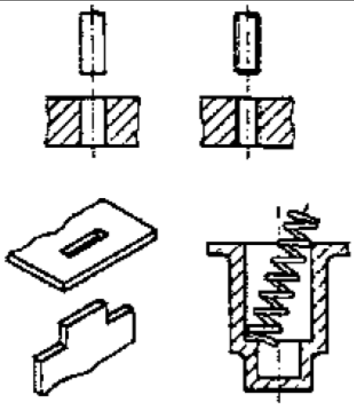
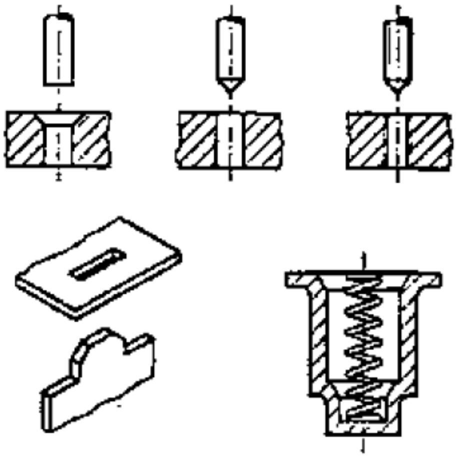
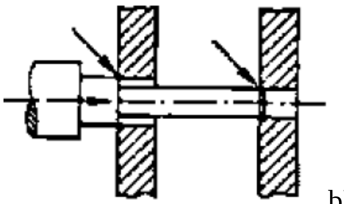
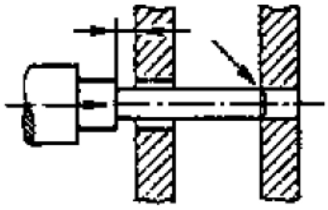
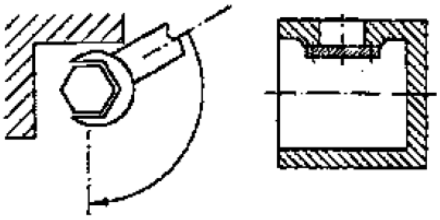
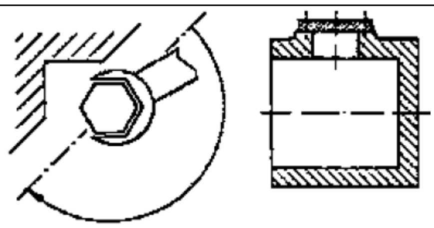
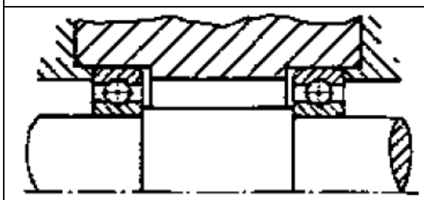
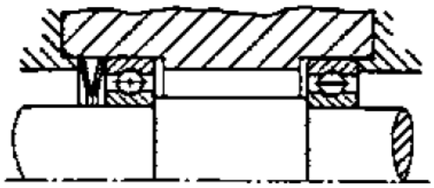


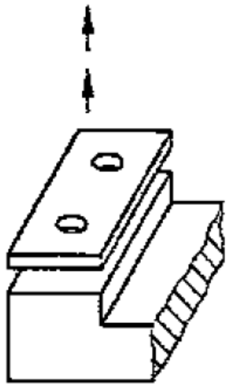
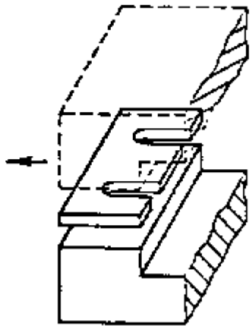
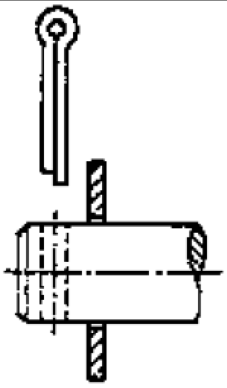


f)

6. **(20)** How can you improve following designs in terms of DFX (Assembly)? Draw sketches and explain.

Text book: Engineering Design, Springer (2007)Pahl_Beitz.pdf, pg.382, Fig.7.125, Embodiment Design

 a) Provide tapering to ease joining	
 b) Avoid simultaneous operations that influence each other.	
 c) Provide access for assembly tools	
 d) Allow for large tolerances through assemply parts that are flexible	

 e) Adapt using standardised matching parts without disassembling	
 f) Apply locking elements that are easy to assemble