ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΑΤΡΩΝ
UNIVERSITY OF PATRAS

ΑΝΟΙΚΤΑ ακαδημαϊκά μαθήματα ΠΠ

Μηχανουργική Τεχνολογία ΙΙ

"Εργαλειομηχανές – **Προγραμματισμός Παραγωγής**"

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Πολυτεχνική Σχολή
Τμήμα Μηχανολόγων & Αεροναυπηγών Μηχανικών

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Manufacturing Processes II

"Machine Tools - **Process Planning**"

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School of Engineering
Dept. of Mechanical Engineering & Aeronautics

MANUFACTURING PROCESSES ALTER A GIVEN MATERIAL'S FORM, SHAPE, AND/OR PHYSICAL PROPERTIES

MANUFACTURING EQUIPMENT

Performs or assists to perform a **manufacturing process**

- **MACHINE TOOLS**
- **ROBOTS AND HANDLING DEVICES**
- **CARTS AND AUTOMATED GUIDED VEHICLES (A.G.V.)**
-
-
-

MACHINE TOOL

A non-portable machine with an integral power source which causes the relative motion of a tool and a workpiece to produce a predetermined geometric form or shape.

- ECONOMIC IMPORTANCE: MAJOR ROLE IN PRODUCING INDUSTRIAL GOODS

- PRODUCT QUALITY/MFG. COST DEPENDS ON MACHINE TOOL TECHNOLOGY

- PROCESS/MATERIALS DEVELOPMENT DRIVES MACHINE TOOL DEVELOPMENT

Machine Tools & Manufacturing Equipment

Major Machine Tool Producing Countries

	1968	1972	1976	1980	1984	1985	1986
USA							
Share of world production	26.3%	14.2%	16.3%	18.2%	12.0%	12.4%	9.7%
Exports/domestic production	12.6%	18.8%	23.6%	15.3%	15.5%	16.6%	19.8%
Imports/domestic consumption	9.8%	10.0%	16.4%	23.3%	38.0%	43.4%	49.2%
Total shipments ($ millions)	1722.8	1269.3	2178.2	4812.4	2412.5	2717.8	2830.0
Share of world exports	10.0%	7.6%	8.5%	7.3%	4.8%	4.7%	4.1%
West Germany							
Share of world production	–	–	18.3%	17.9%	14.0%	14.5%	17.8%
Exports/domestic production	68.3%	55.7%	70.2%	62.6%	59.6%	62.2%	60.2%
Imports/domestic consumption	21.4%	22.1%	27.7%	32.8%	35.3%	23.3%	34.8%
Total shipments ($ millions)	–	–	2450.0	4750.0	2803.8	3168.6	5210.1
Share of world exports	28.9%	27.4%	28.5%	24.8%	22.3%	20.3%	22.9%
Japan							
Share of world production	7.5%	7.5%	7.9%	14.5%	22.3%	24.3%	24.2%
Exports/domestic production	10.6%	13.4%	34.9%	37.9%	38.9%	41.1%	41.3%
Imports/domestic consumption	18.6%	12.2%	9.3%	8.5%	6.2%	6.6%	5.6%
Total shipments ($ millions)	488.9	675.6	1058.9	3830.3	4474.6	5316.7	7081.6
Share of world exports	3.6%	7.6%	7.2%	13.2%	21.5%	22.6%	21.4%

Machine Tools & Manufacturing Equipment

- *Manufacturing Equipment* ranges from hand tools to complex automated machining centers.
- *Machine tools* have been used in industrial production for over 100 years.
- *Manufacturing Equipment* and *Machine tools* are the critical link between intermediate products formed from raw materials and finished discrete parts and components.

Machine Tools & Manufacturing Equipment

The Evolution of the Lathe

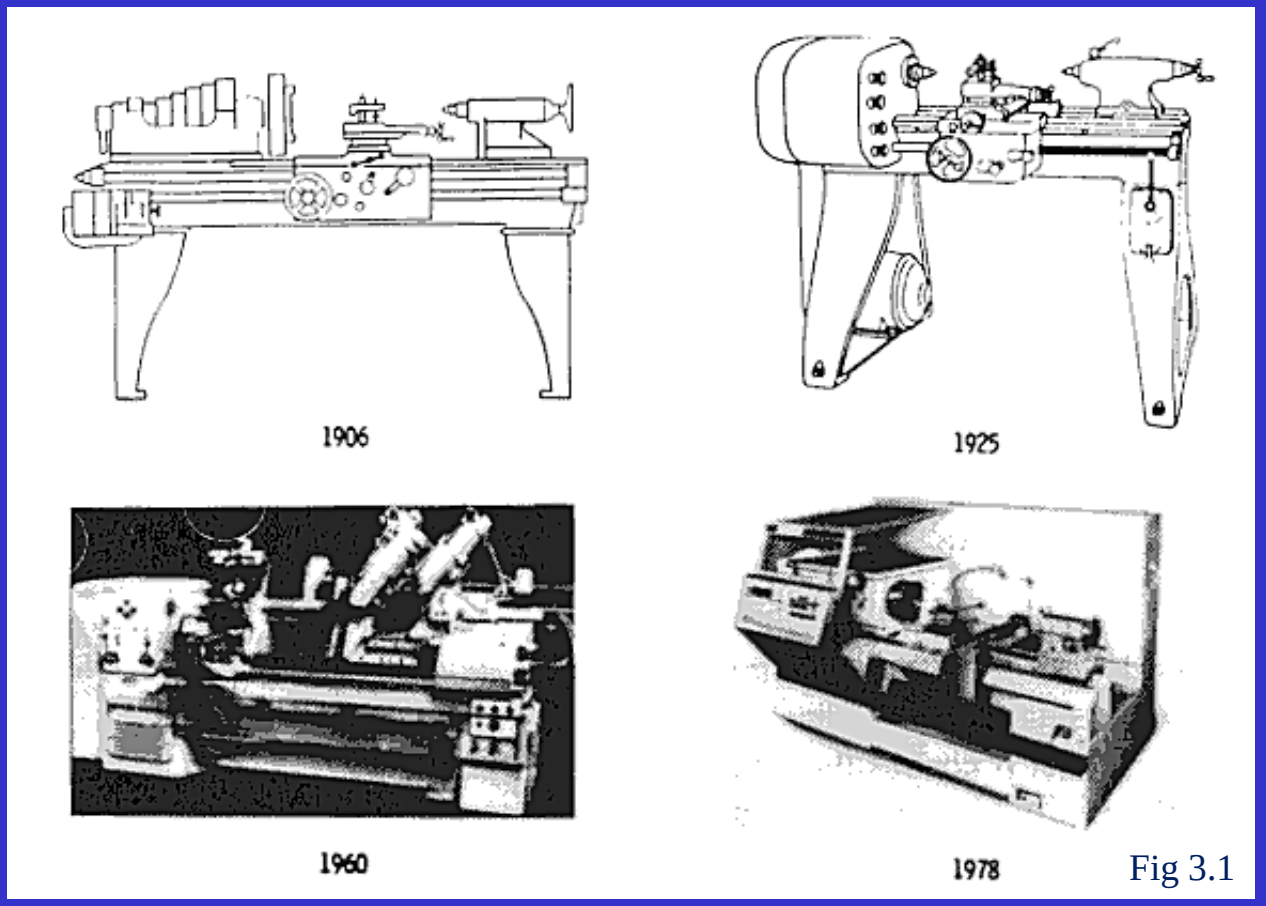


Fig 3.1

Machine Tools & Manufacturing Equipment

Historical Development of Tool Materials

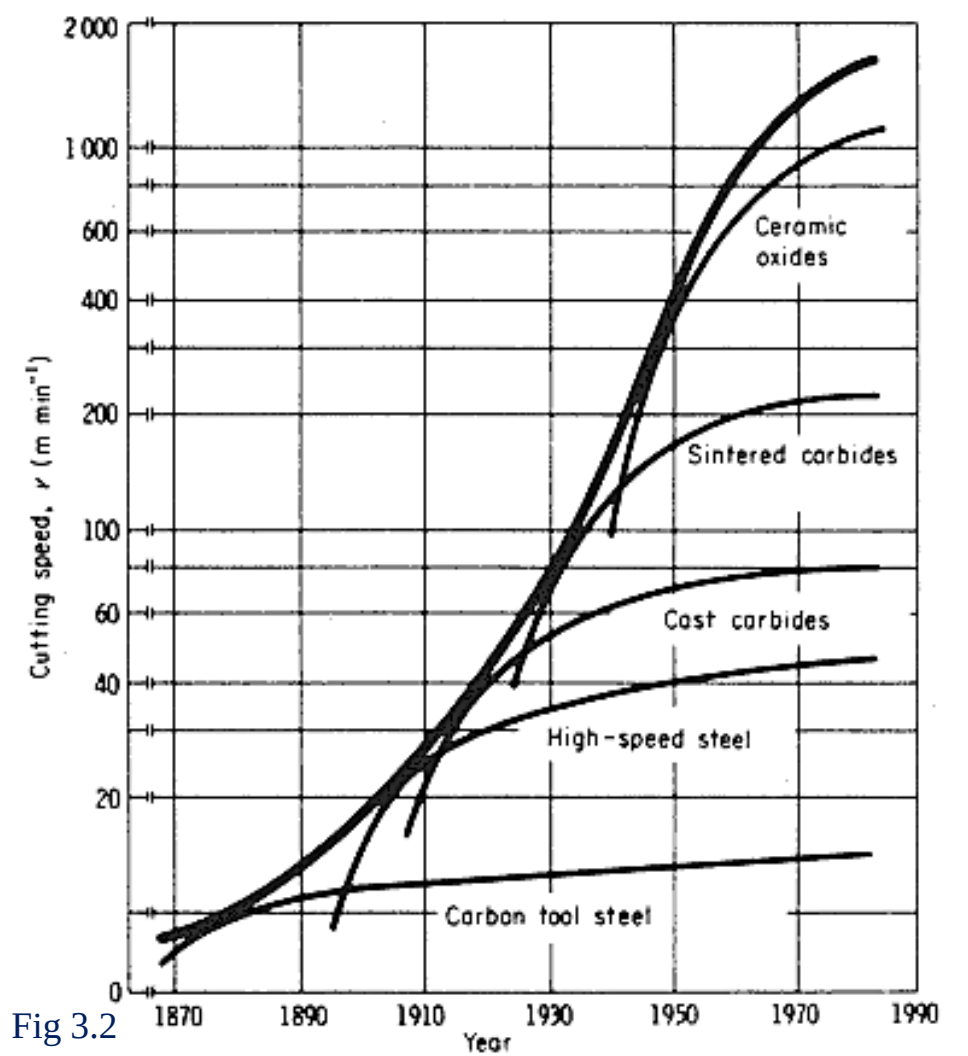


Fig 3.2

MANUFACTURING PROCESSES

- Primary Forming: Original creation of a shape/molten, gaseous, solid

  Cohesion is created

- Deforming: Change the shape of a solid without changing the mass or material composition

  Cohesion is maintained

- Removing: Removal of Material

  Cohesion is destroyed

- Joining: Unite Individual Work pieces

  Cohesion is increased

- Changing Material Properties: Purposely change workpiece characteristics to achieve desirable properties.

DEFORMING PROCESSES

- According to the stresses experienced by the material
  - Compressive
  - Tensile
  - Compressive & Tensile
  - Bending
  - Shearing

- According to the temperature of the material during forming
  - Hot forming
  - Cold forming

- According to changes in mechanical properties
  - With no change in mechanical properties
  - With temporary changes
  - With permanent changes

METAL (DE)FORMING

Technological Characteristics

- High loads and stresses
  - The entire workpiece deforms (or a substantial part of it)
    50-2.500 N/mm^2 or up to 300.000 psi
  - Forging presses up to 750 MN (85 kilotons)
  - Cutting machinery 20 KN (2,3 tons)

- Tools are large, heavy, and often expensive
  - Special machining methods
  - Special skills
  - High volume to justify the cost/minimum quantity

- Advantages
  - Short production times
  - Often high accuracy
  - Good mechanical properties

TYPICAL PRODUCTS MADE BY DEFORMING PROCESSES

1. Components for automobiles and machine tools as well as for industrial plants and equipment. Here metal forming is a vital link in the development of modern design in light alloys.

2. Hand tools, such as hammers, pliers. Screwdrivers, and surgical instruments.

3. Fasteners, such as screws, nuts, bolts, and rivets.

4. Containers, such as metal boxes, cans, and canisters.

5. Construction elements used in tunnelling, mining, and quarrying (roofing and walling elements, pit props, etc.)

6. Fittings used in the building industry, such as for doors and windows.

MACHINE TOOLS FOR DEFORMING

(converting a given shape of a solid to another shape without change in mass or material composition/maintaining cohesion)

MACHINE CLASSIFICATION BASED ON THE MAIN STRESSES EXPERIENCED BY THE MATERIAL DURING THE PROCESS:

MACHINES FOR:

- COMPRESSION FORMING
- TENSION FORMING
- TENSION/COMPRESSION FORMING
- BENDING

...

MACHINE TOOLS FOR DEFORMING

MACHINE CLASSIFICATION BASED ON THE TEMPERATURE EXPERIENCED BY THE MATERIAL DURING THE PROCESS:

MACHINES FOR:

- COLD FORMING/ROOM TEMPERATURE
- HOT FORMING/TEMPERATURE ABOVE RECRYSTALLIZATION

MACHINE CLASSIFICATION BASED ON FUNCTIONAL PRINCIPLE:
MACHINE CAPACITY CHARACTERIZED BY:

- ENERGY
- MOVEMENT
- FORCE

Machines for Deforming

Linear Tool Movement

(a) Rolling (b) Drawing (c) Upsetting

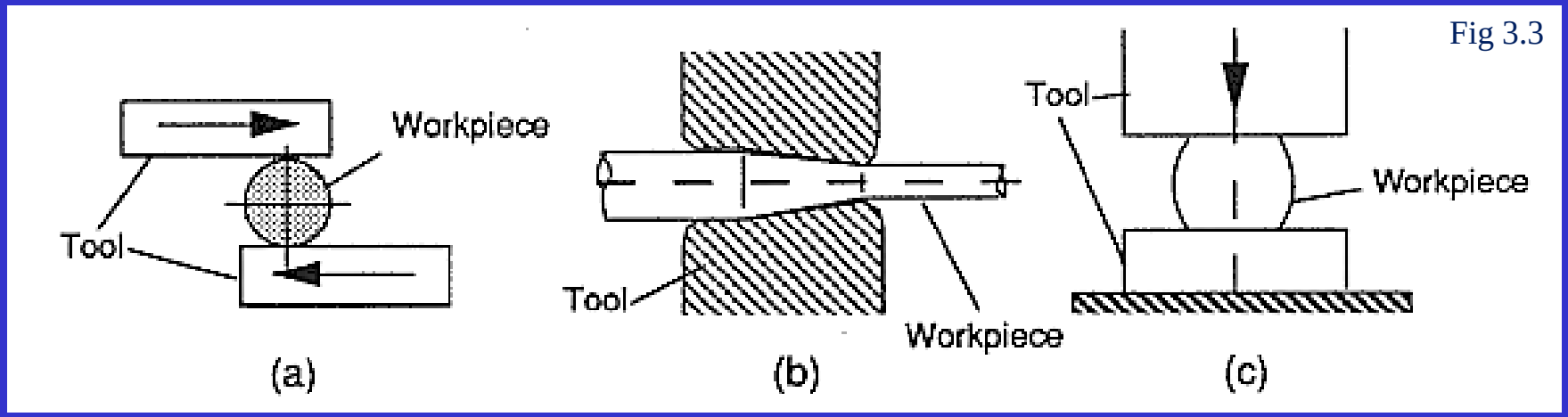


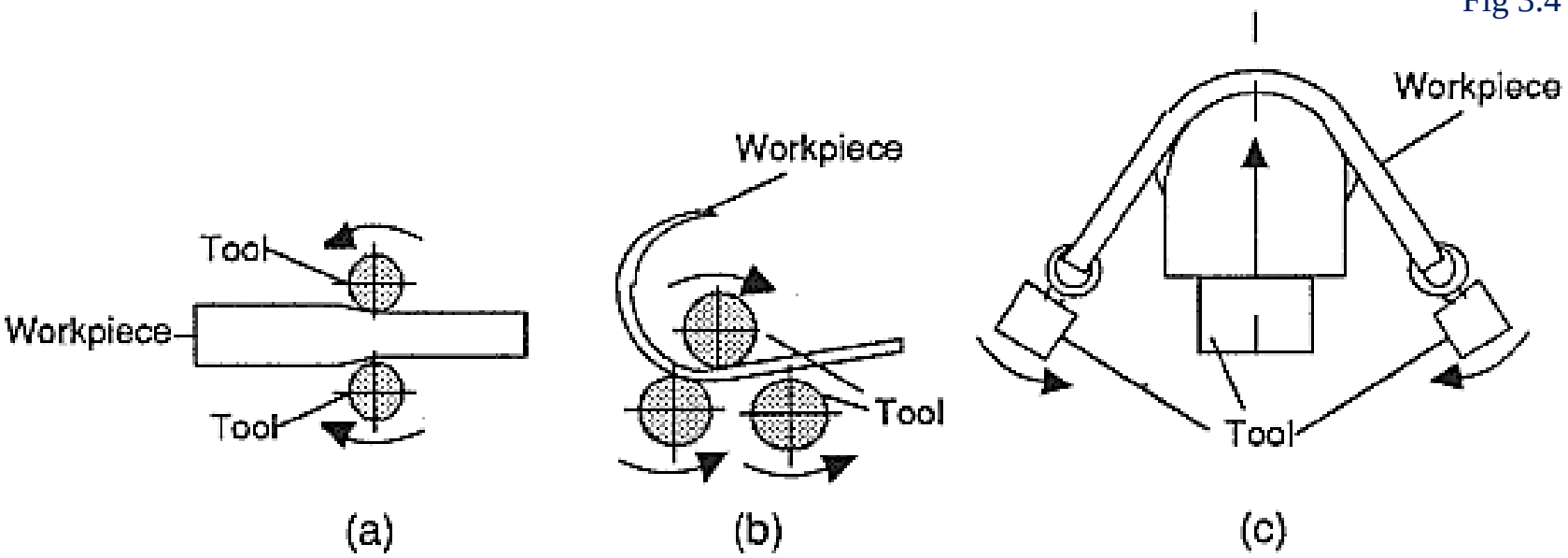
Fig 3.3

Machines for Deforming

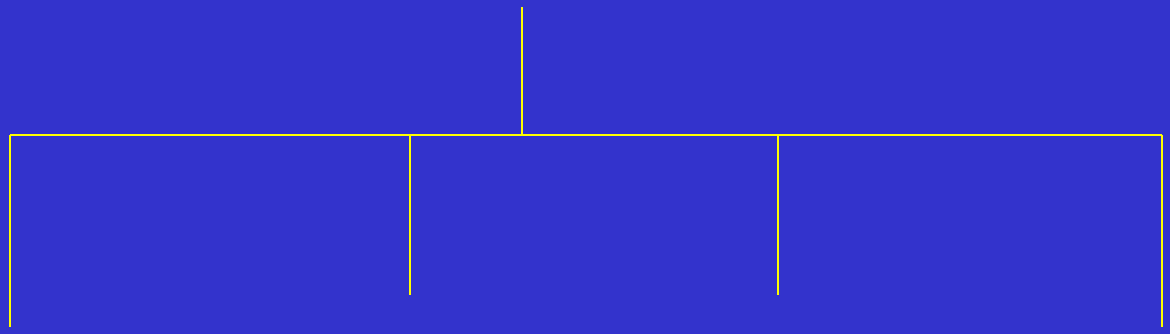
Non-linear Tool Movement

(a) Rolling (b) Bending (c) Stretch-Forming

Fig 3.4



Material Removal



Mechanical Mechanism

Thermal Mechanism

Electrochemical Mechanism

Chemical Mechanism

MACHINE TOOLS FOR SEPARATING
(machining or removal of material/*destroying cohesion*).

MACHINES FOR SEPARATING WITH NO CHIP REMOVAL

* SHEARING MACHINES
* NIBBLING MACHINES
* LASER CUTTING MACHINES

E.T.C.

MACHINES FOR SEPARATING WITH CHIP REMOVAL

MACHINES USING SINGLE-CUTTING -EDGE TOOL

MAIN CUTTING MOTION: TRANSLATORY

* PLANNING MACHINES
* SHAPING MACHINES
* BROACHING MACHINES

E.T.C.

MAIN CUTTING MOTION : ROTARY

* LATHES
* DRILLING MACHINES
* MILLING MACHINES, E.T.C. ...

MACHINE TOOLS FOR SEPARATING

(machining or removal of material/*destroying cohesion*).

MACHINES USING NO SINGLE-CUTTING-EDGE TOOL

MAIN CUTTING MOTION : TRANSLATORY/ROTARY

* GRINDING MACHINES
* HONING MACHINES
* LAPPING MACHINES

E.T.C.

NON TRADITIONAL CUTTING TECHNIQUES

* LASER MACHINES
* E.D.M MACHINES
* E.C.M MACHINES

E.T.C.

MACHINE TOOLS ELEMENTS

- **FRAMES**

  LOAD CARRYING BODIES WHICH SUPPORT INDIVIDUAL CONSTRUCTIONAL/FUNCTIONAL MACHINE ELEMENTS.

- **GUIDEWAYS AND BEARINGS**

  CONSTRUCTION UNITS WHICH GUIDE/SUPPORT MACHINE TOOL MOTIONS

- **MAIN DRIVES**

  DRIVE UNITS WHICH PROVIDE THE MAIN WORKING MOTIONS OF A MACHINE TOOL.

- **FEED DRIVES**

  DRIVE UNITS WHICH PROVIDE THE MOTIONS OF THE TOOL AND/OR WORKPIECE REQUIRED TO PRODUCE A GIVEN CONTOUR ON THE WORKPIECE.

MACHINE FRAMES

- **REQUIREMETS/MATERIALS**
- **FORCE FLUX AND DEFORMATION**
- **STATIC LOADS**
- **DYNAMIC LOADS**
- **THERMAL LOADS**
- **COMPUTATION METHODS**

REQUIREMENTS/MATERIALS

- OVERALL DESIGN GOAL:

TO MINIMIZE UNDESIRED RELATIVE DISPLACEMENT BETWEEN TOOL AND WORKPIECE DUE TO THE PROCESS

- MODULAR DESIGN WITH JOINTS
- SIZE/FORM/SHAPE OF FRAME ELEMENTSDEPENDS UPON:
  - POSITION OF MOVING AXES
  - LENGTH OF MOVING A XES
  - DIRECTION/MAGNITUDE OF PROCESS FORCES
  - ACCESSIBILITY
  - MANUFACTURABILITY

- MATERIALS:
  - STEEL
  - CAST IRON
  - ALUMINUM
  - COPPER
  - BRASS
  - TITANIUM
  - CONCRETE
  - COMPOSITES(?)

Frames: “C” and “O” Types

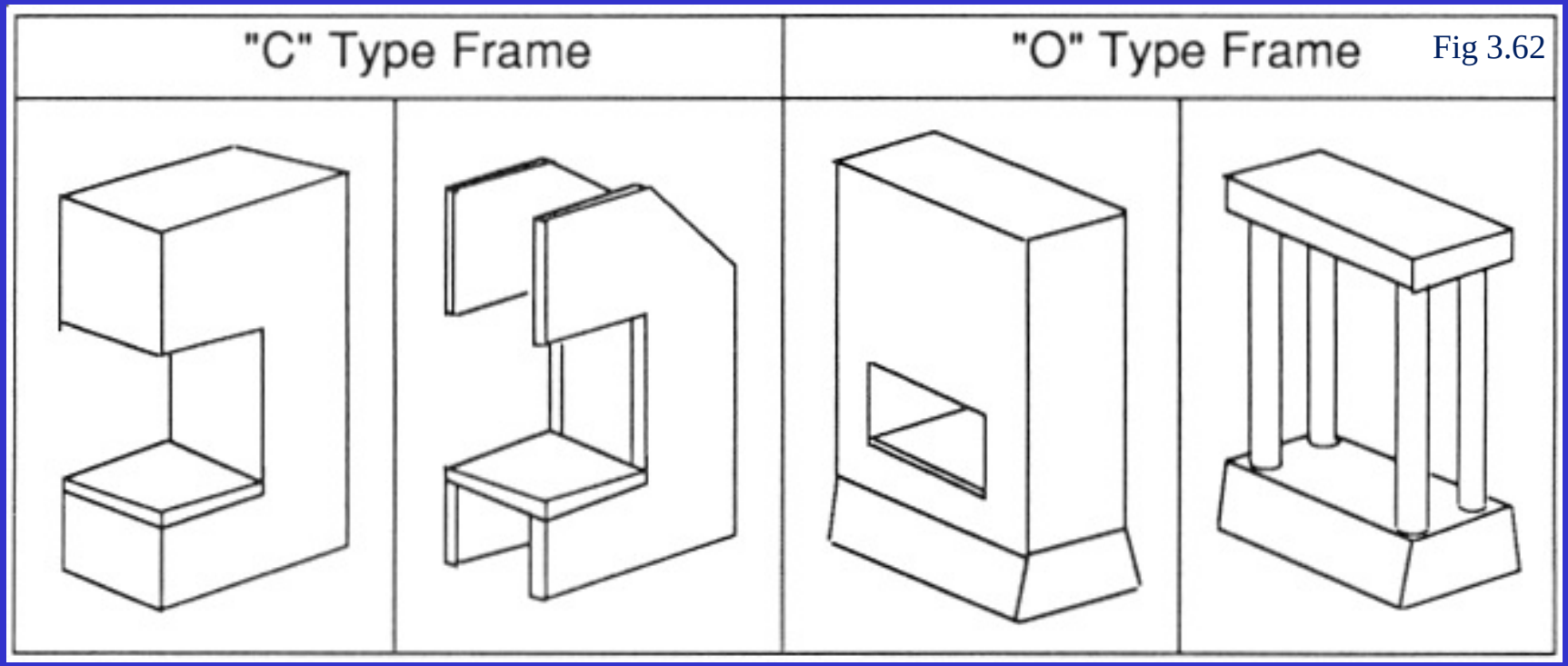
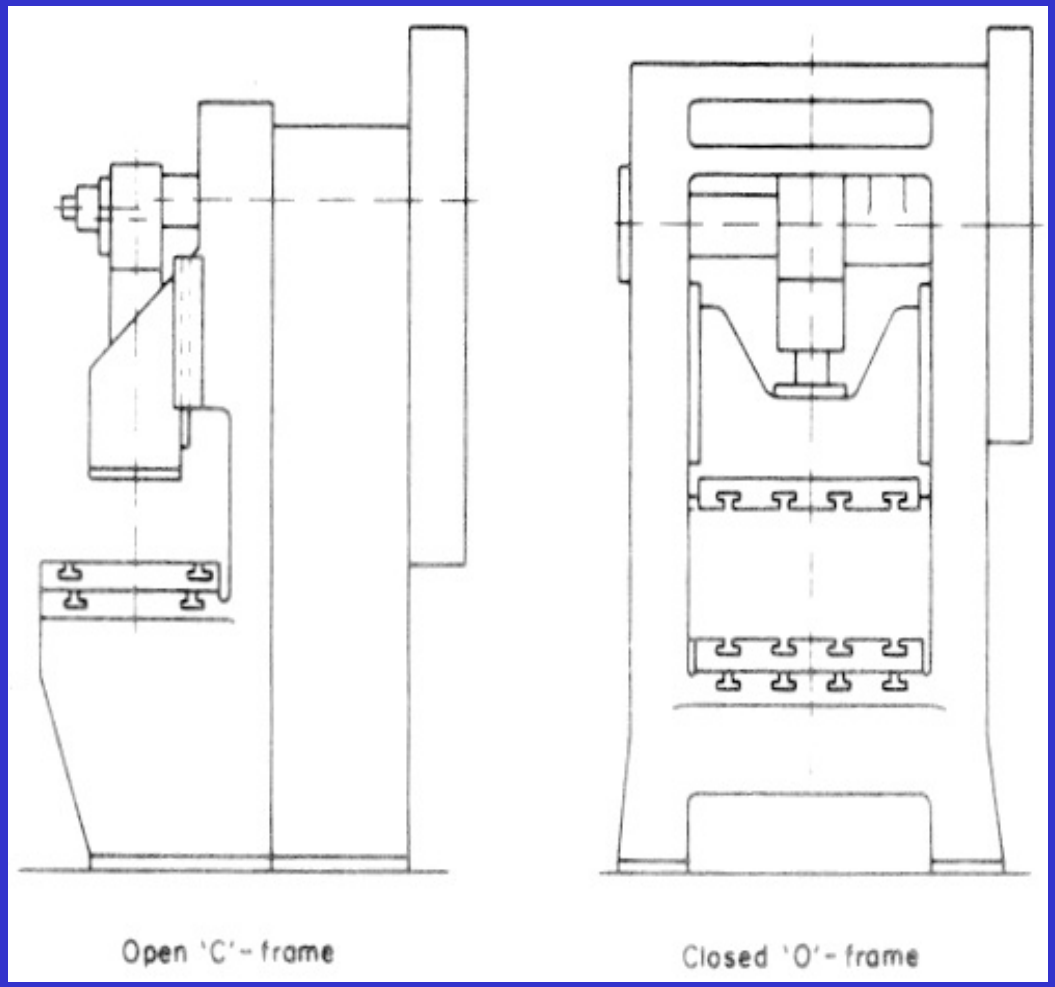


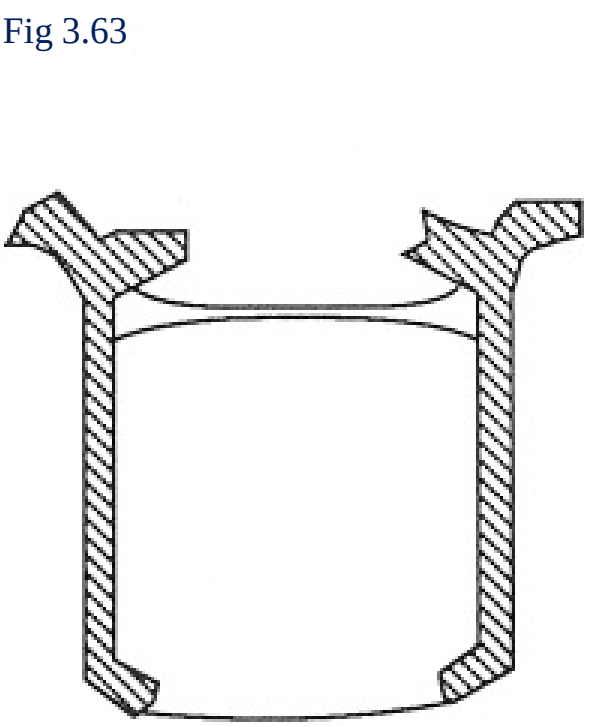
Fig 3.62

Frames:
“C” and “O” Types

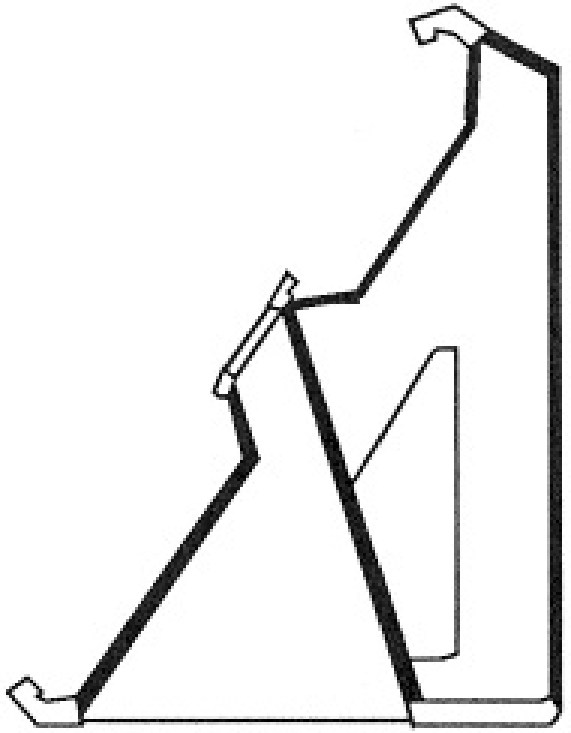


Frames: Bed Constructions

Fig 3.63



(a) Manual Lathe



(b) Automatic Lathe

Frames
(*Static Behaviour*)
Horizontal Milling Machine:
Force Flux

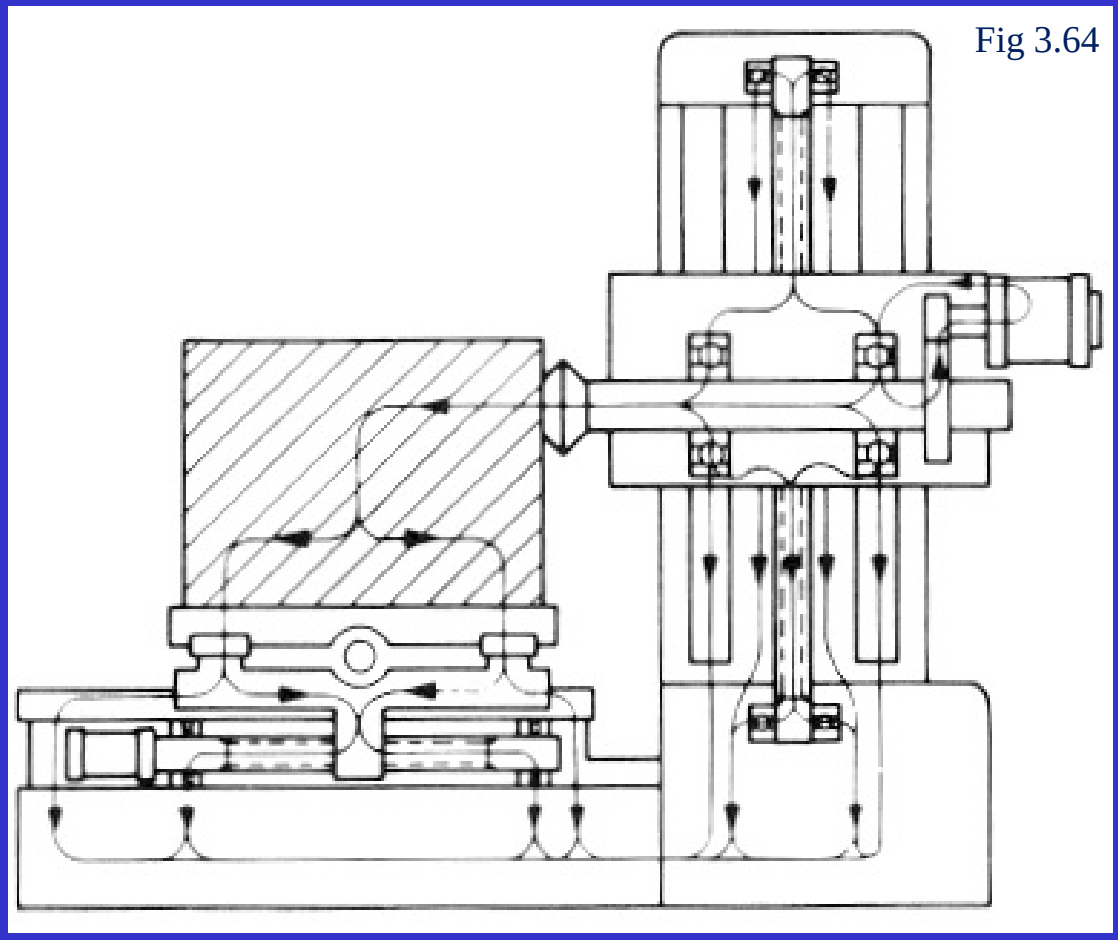
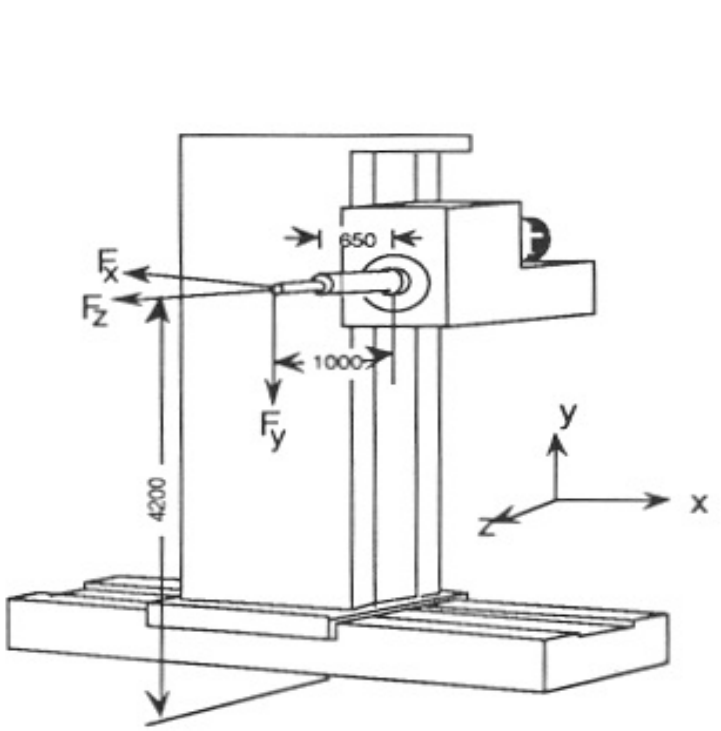


Fig 3.64

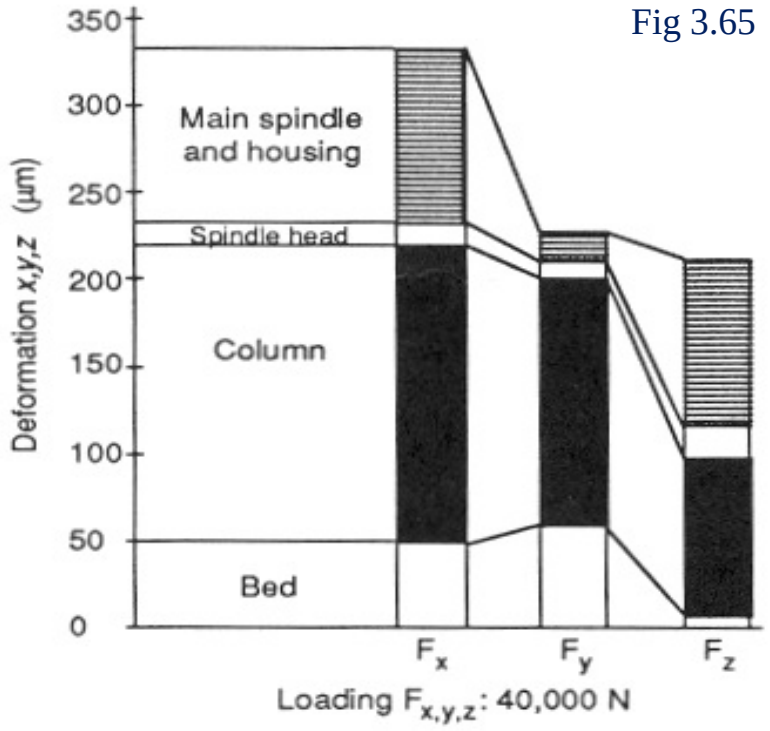
Frames (*Static Behaviour*)

Horizontal Milling Machine: *Forces & Deflections*

Fig 3.65



(a)



(b)

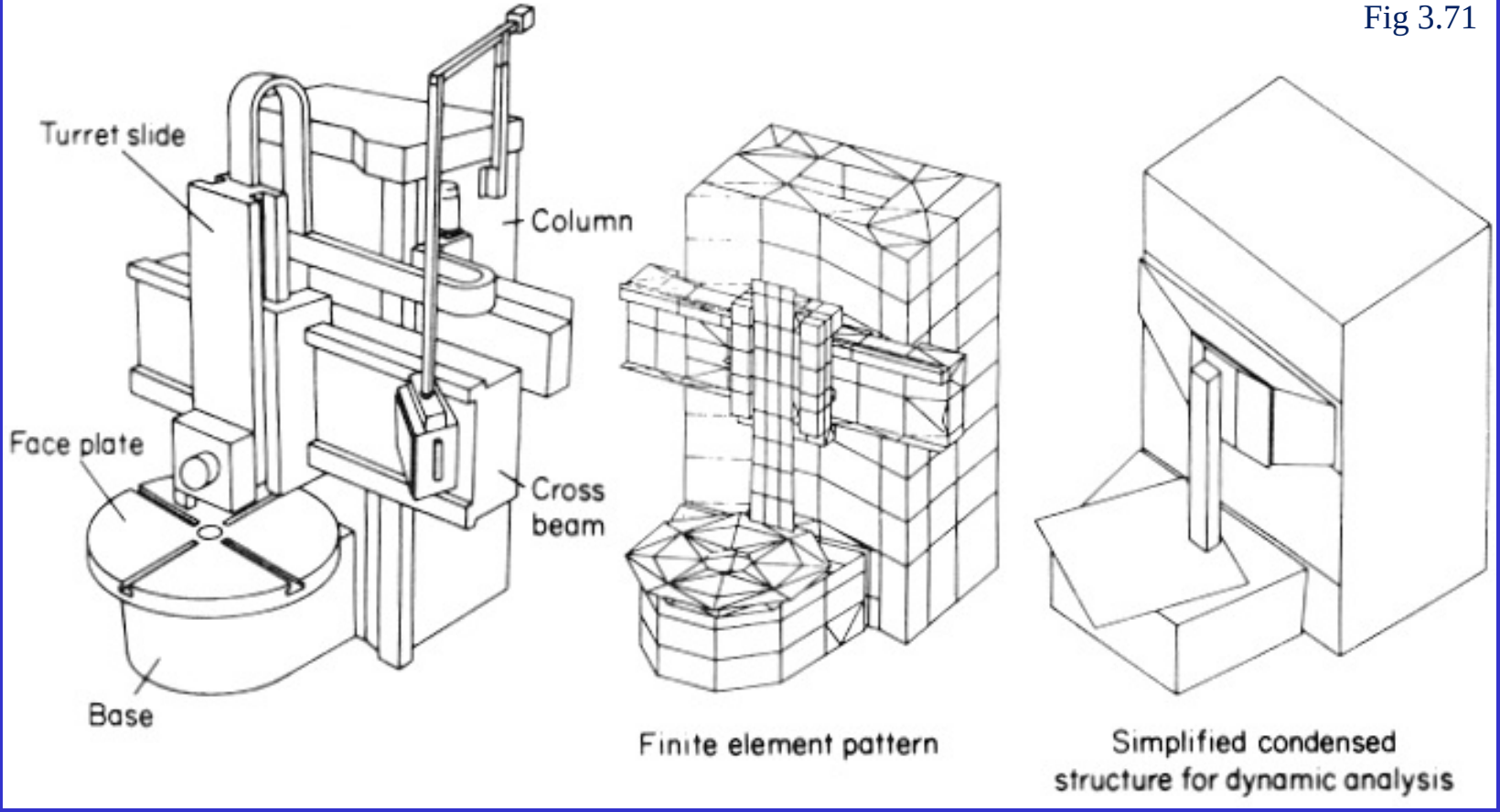
COMPUTATION METHODS FOR FRAMES

- THEORY OF ELASTICITY
  - EXACT SOLUTIONS
    - SIMPLIFIED PROBLEM USING ADEQUATE ASSUMPTIONS
- APPROXIMATIONS
  - ANALYTICAL METHODS
  - NUMERICAL METHODS
    - FINITE DIFFERENCES
    - FINITE ELEMENTS

Frames (*Static Behaviour*)

A Finite Element Model of a Milling Machine

Fig 3.71



DYNAMIC LOADS

- TIME CHANGING PROCESS FORCES
- MOVING MACHINE MASSES
- FLOOR MOTIONS

THEY RESULT IN MACHINE VIBRATIONS

- INDEPENDENTLY EXCITED
- SELF-EXCITED

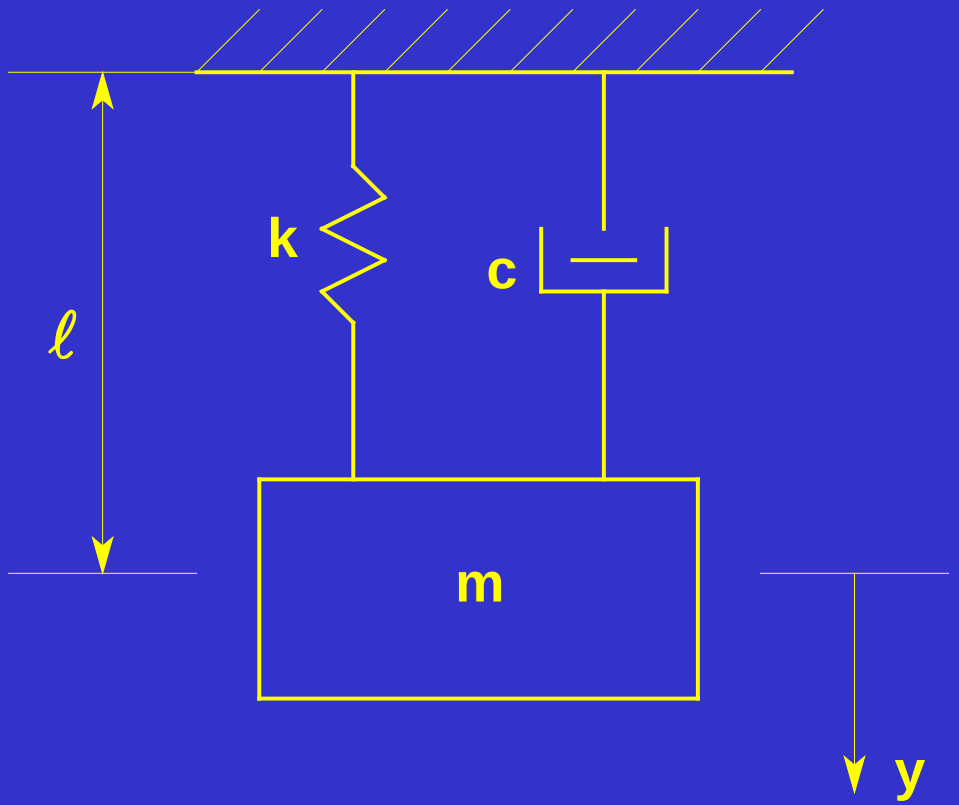
DYNAMIC BEHAVIOUR OF MACHINE TOOLS:

- MASS DISTRIBUTION
- STIFFNESS
- DAMPING

…

System Analysis

Spring
Mass
Dashpot



+ **y** : Downwards
– **y** : Upwards

GUIDEWAYS AND BEARINGS

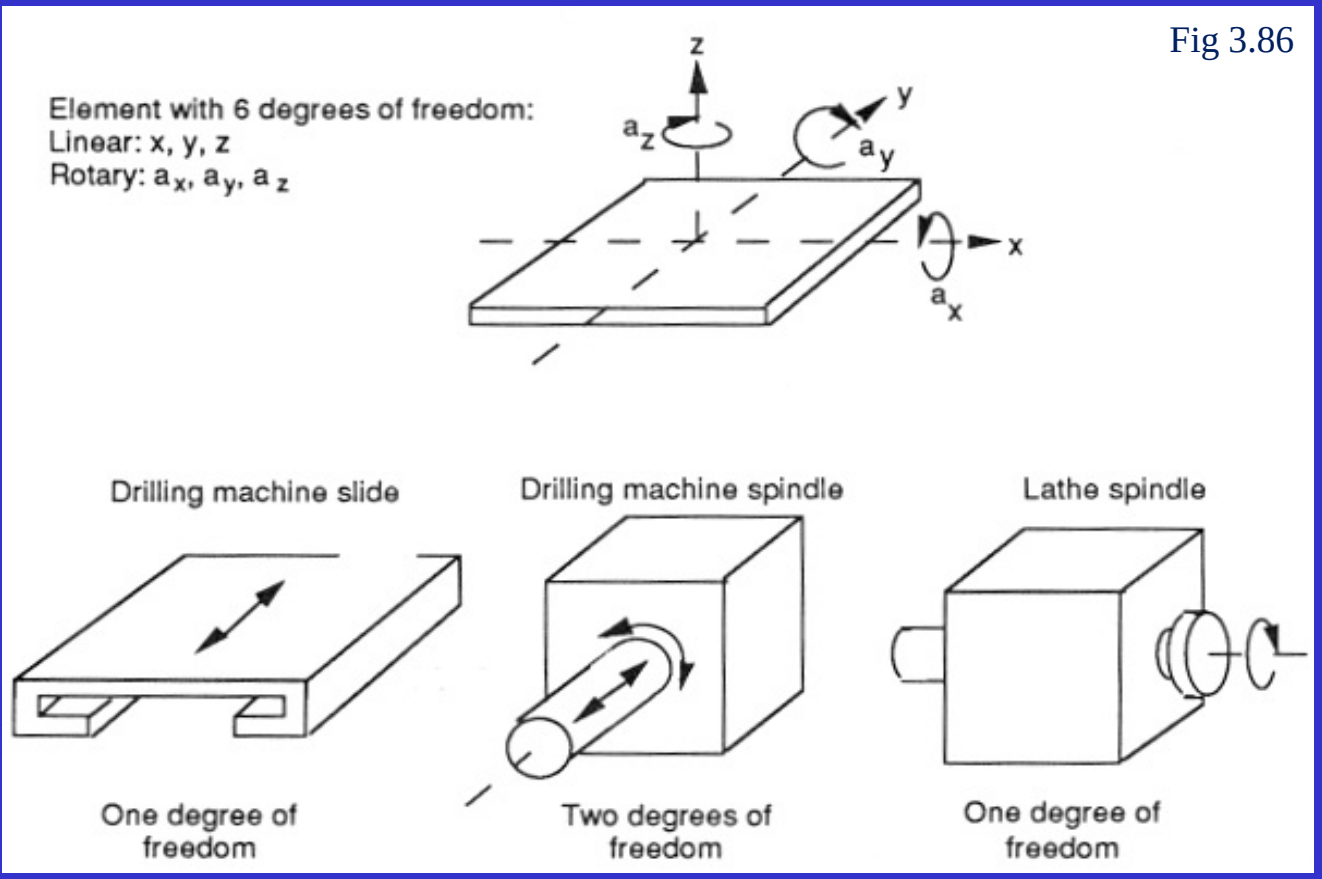
CLASSIFICATION ACCORDING TO:

- TYPE OF MOVEMENT/DEGREES OF FREEDOM
  - LINEAR
  - ROTARY
  - COMBINATION OF ABOVE
- CONTACT CONDITIONS/LUBRICATION
  - HYDRODYNAMIC
  - HYDROSTATIC
  - AERODYNAMIC
  - AEROSTATIC
  - ROLLING

Guideways & Bearings

Degrees of Freedom

Fig 3.86



Guideways & Bearings

Type Examples

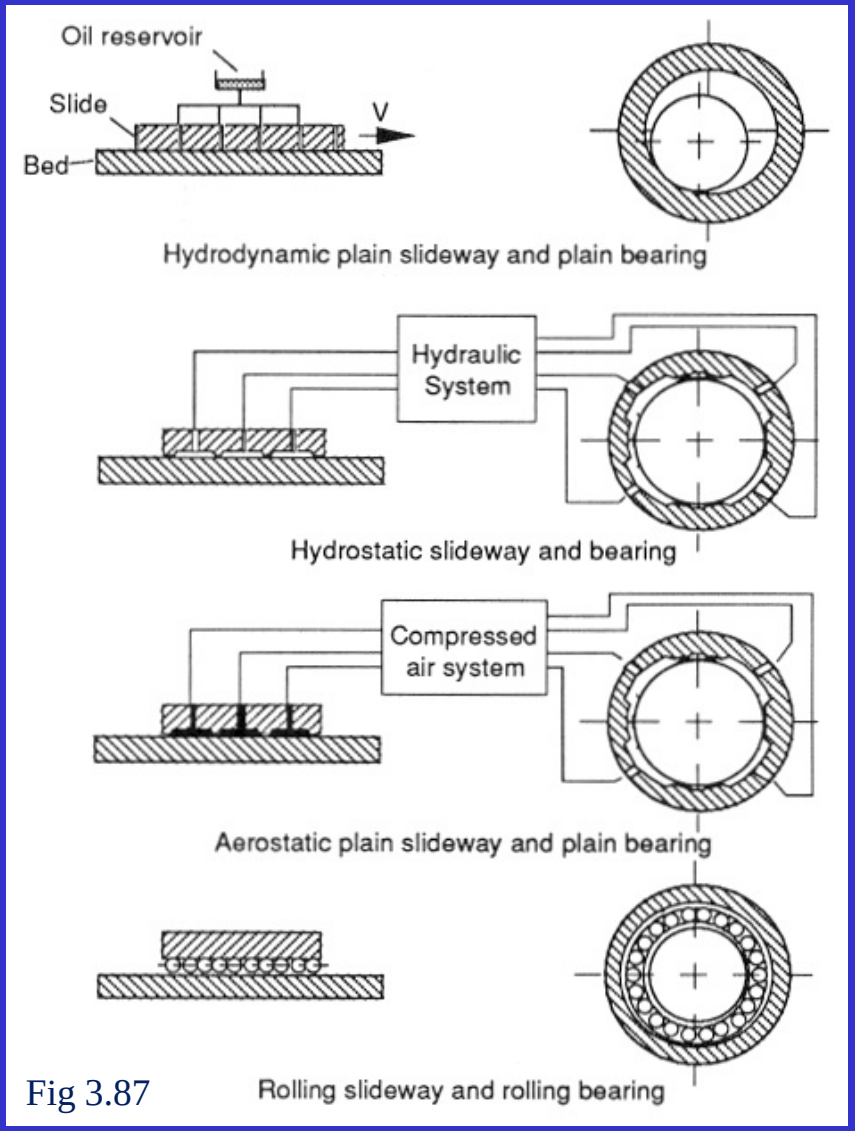


Fig 3.87

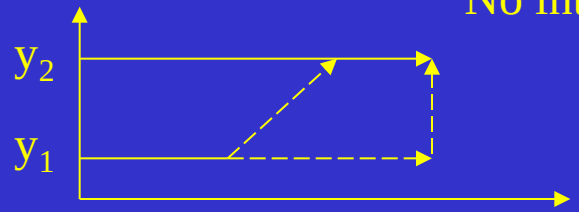
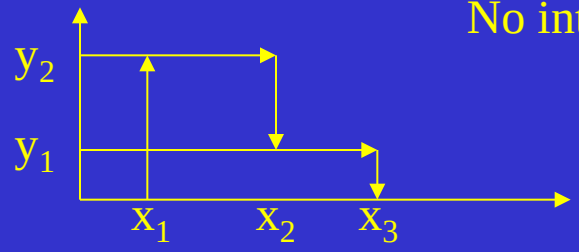
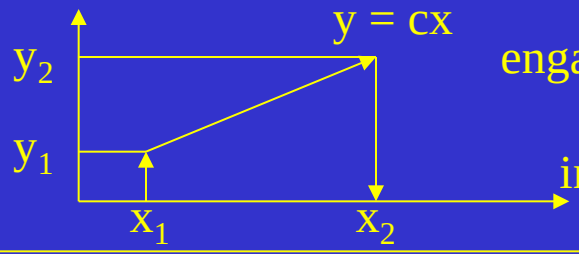
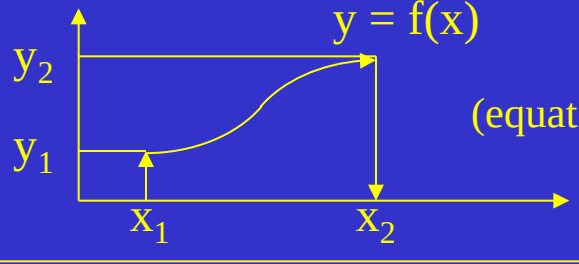
CONTROL FUNTIONS OF MACHINE TOOLS

- **AUTOMATION STAGES**

DRIVING FORCE

- **HIGHER PRODUCTIVITY** (faster and easier manufacture of increasing quantities)
- **HIGHER LABOUR COST** (higher wages/less working hours)
- **BETTER WORK CONTENT** (jobs with greater interest and satisfaction
- **HIGHER FLEXIBILITY** (one-off / small quantity production)

Fig 3.119

Type of Control	Problem	Tool Action	Application
Point -to-point or positional control		No cutting during table movement	Drilling, spot welding
Line -motion control (simple)		Cutting during table movement	Parallel turning, milling
Line -motion control with linear interpolation		Cutting during table movement	Turning, Milling
Continuous path or contour control		Cutting during table movement	Turning, Milling, Flame cutting (any contour)

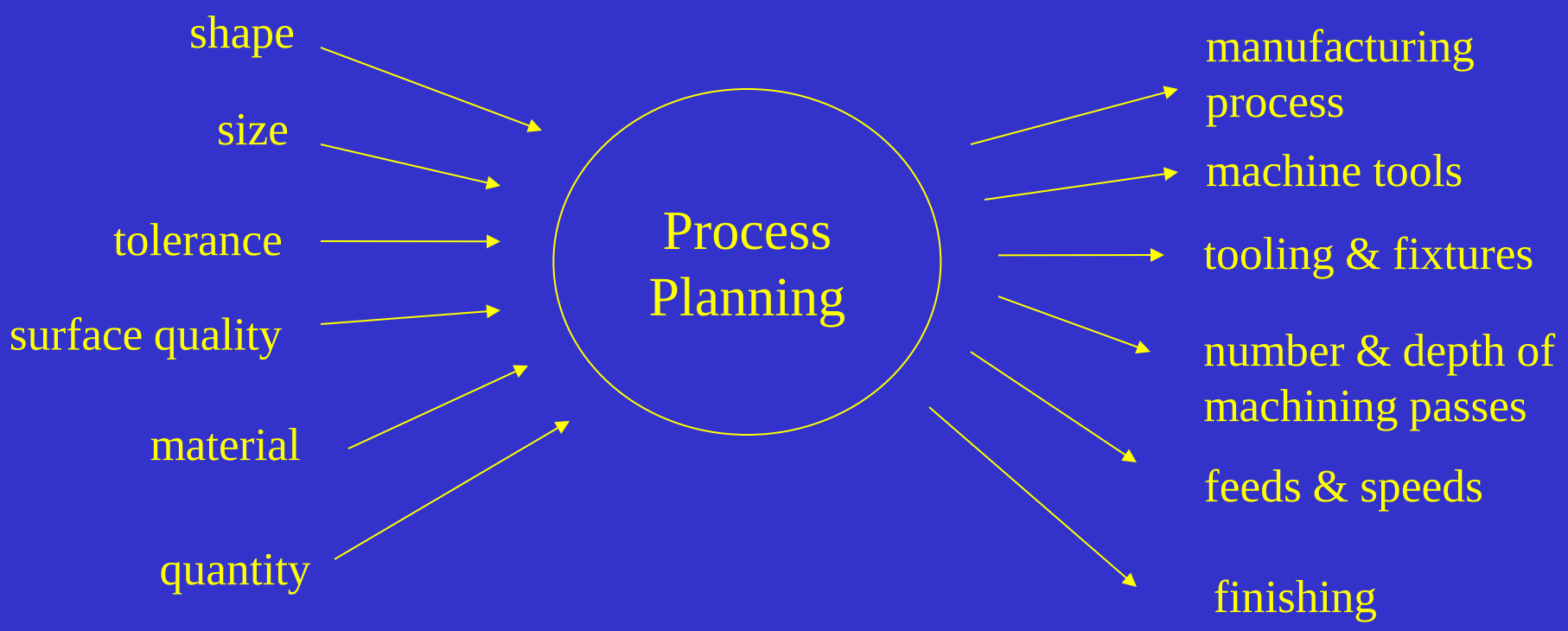
The Process Planning Function

Establish the sequence of the manufacturing processes to be used in order to convert a part from an initial to a final form.

Sequence incorporates:

- process description
- process parameters
- equipment and tool selection

Process Planning



Computer Aided Process Planning

Variant: Uses library retrieval procedures to find standard plans for similar components

Generative: Plans generated automatically for new components without reference to existing plans

Variant Process Planning Stages

Preparatory Stage:

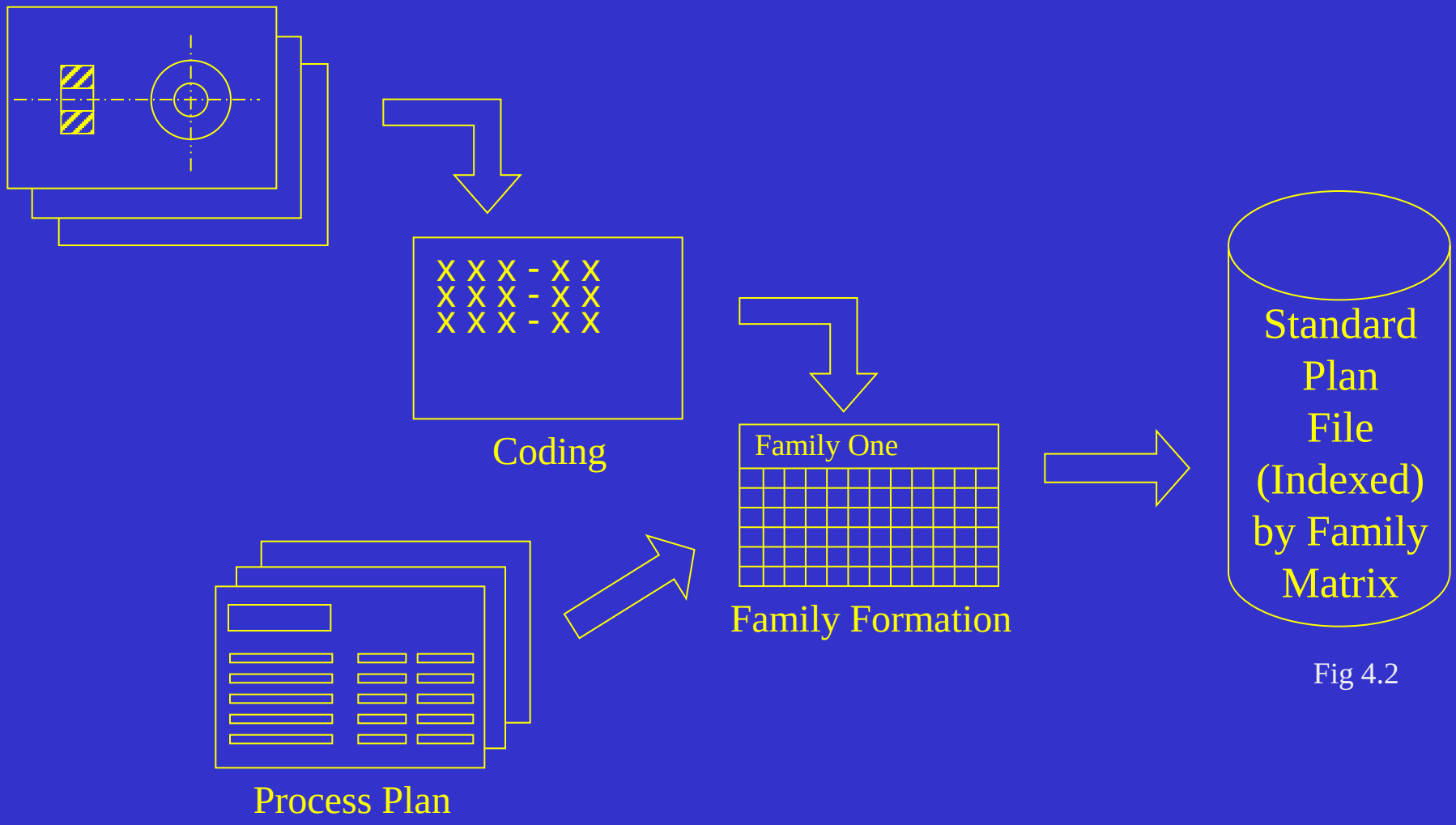


Fig 4.2

Variant Process Planning Stages

Production Stage:

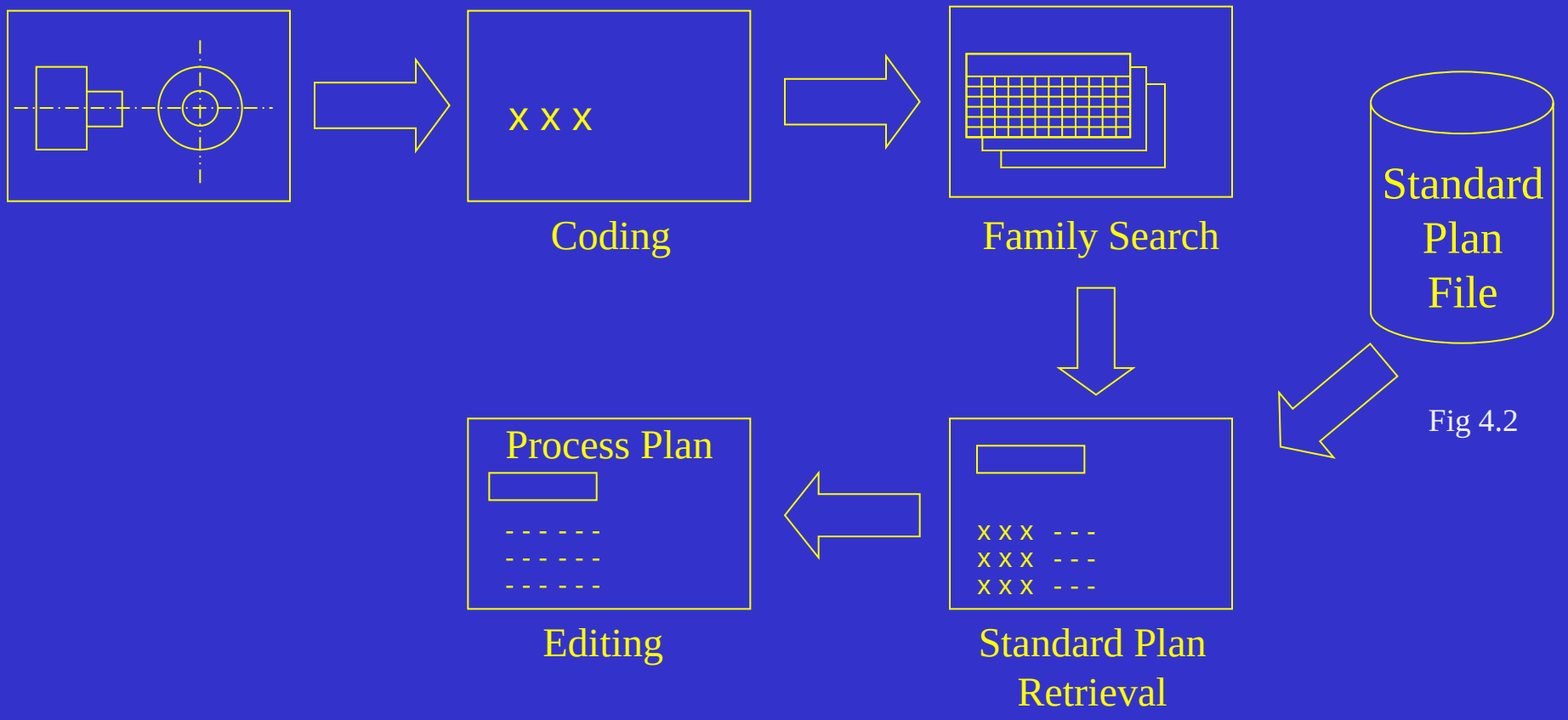


Fig 4.2

Funding

- This educational material has been developed in the teaching duties of the respective educator.
- The project «**Open Academic Courses at the University of Patras**» has funded only the reformation of the education material.
- The Project is implemented within the context of the Operational Programme “Education and Lifelong Learning” (EdLL) and is co-funded by the European Union (European Social Fund) and national resources.

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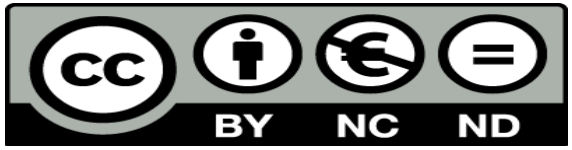

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