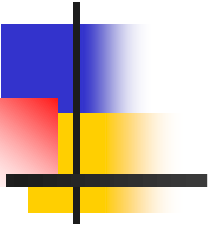
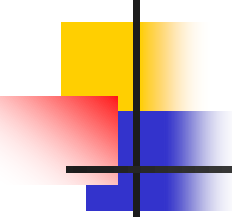


IEng: 5361-Industrial Management and Engineering Economy



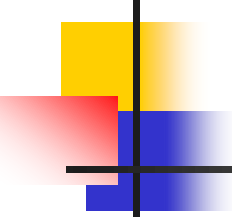
Chapter 2

Plant Design and Ergonomics



Learning Objectives

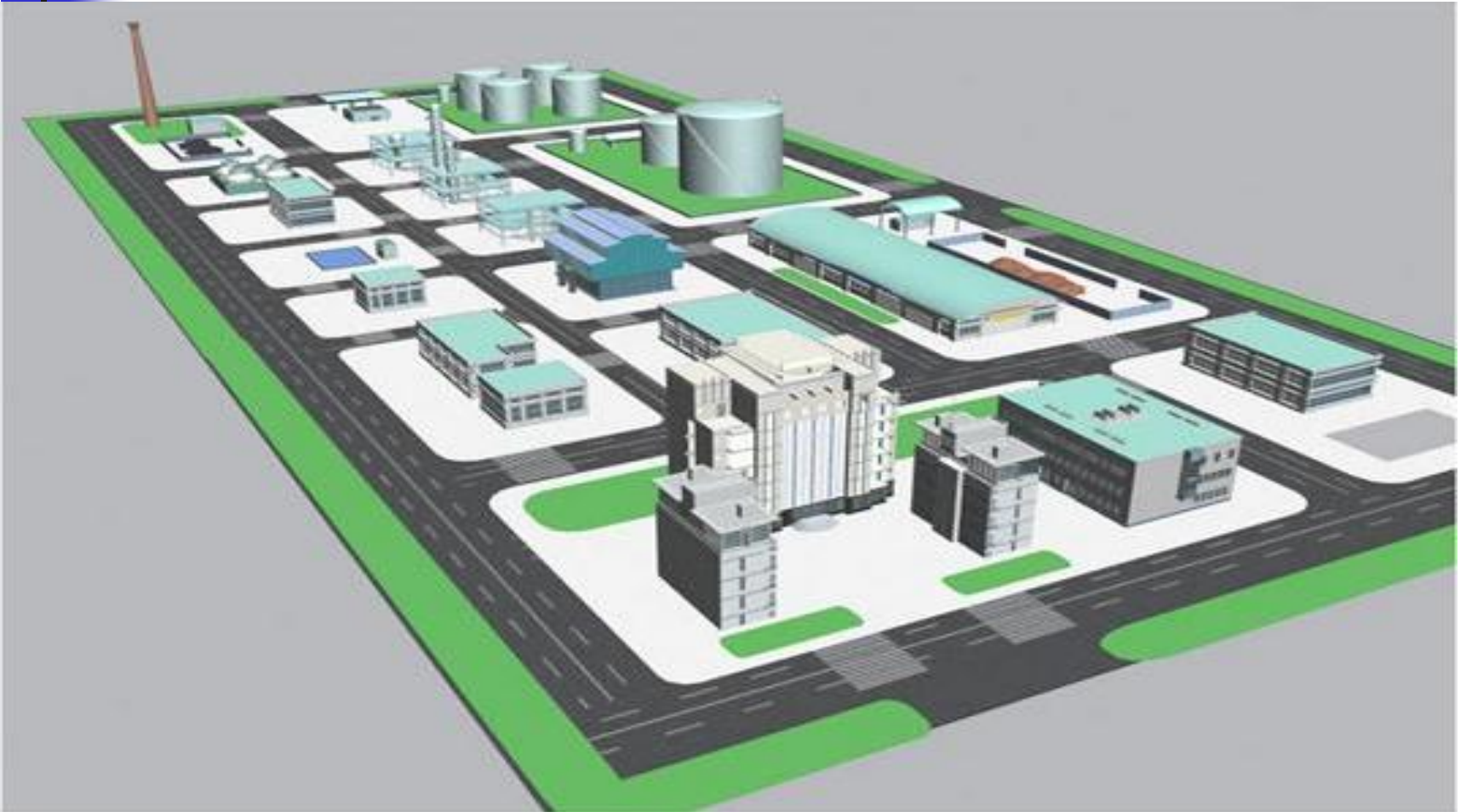
- *Define plant layout and explain its importance*
- *Identify and describe different types of layouts*
- *Identify factors that affect plant layout and locations*
- *understand principles and procedures of plant layout*
- *Understand the concept of ergonomics and industrial safety*

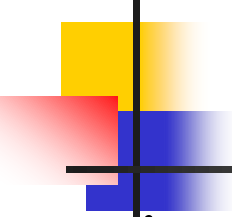


What is plant design?

- Plant design is an **overall design** of an enterprise.
- It is the **planning** of **Finance**, **plant location** and the planning necessary for the **physical requirements** of an overall design of plant.
- It is the plan or the act of planning an **optimal arrangement** of industrial **facilities**, operating **equipment**, storage **space**, material **handling equipment** and other **supporting service** along with the design of the best structure to contain these facilities.

What is plant design?

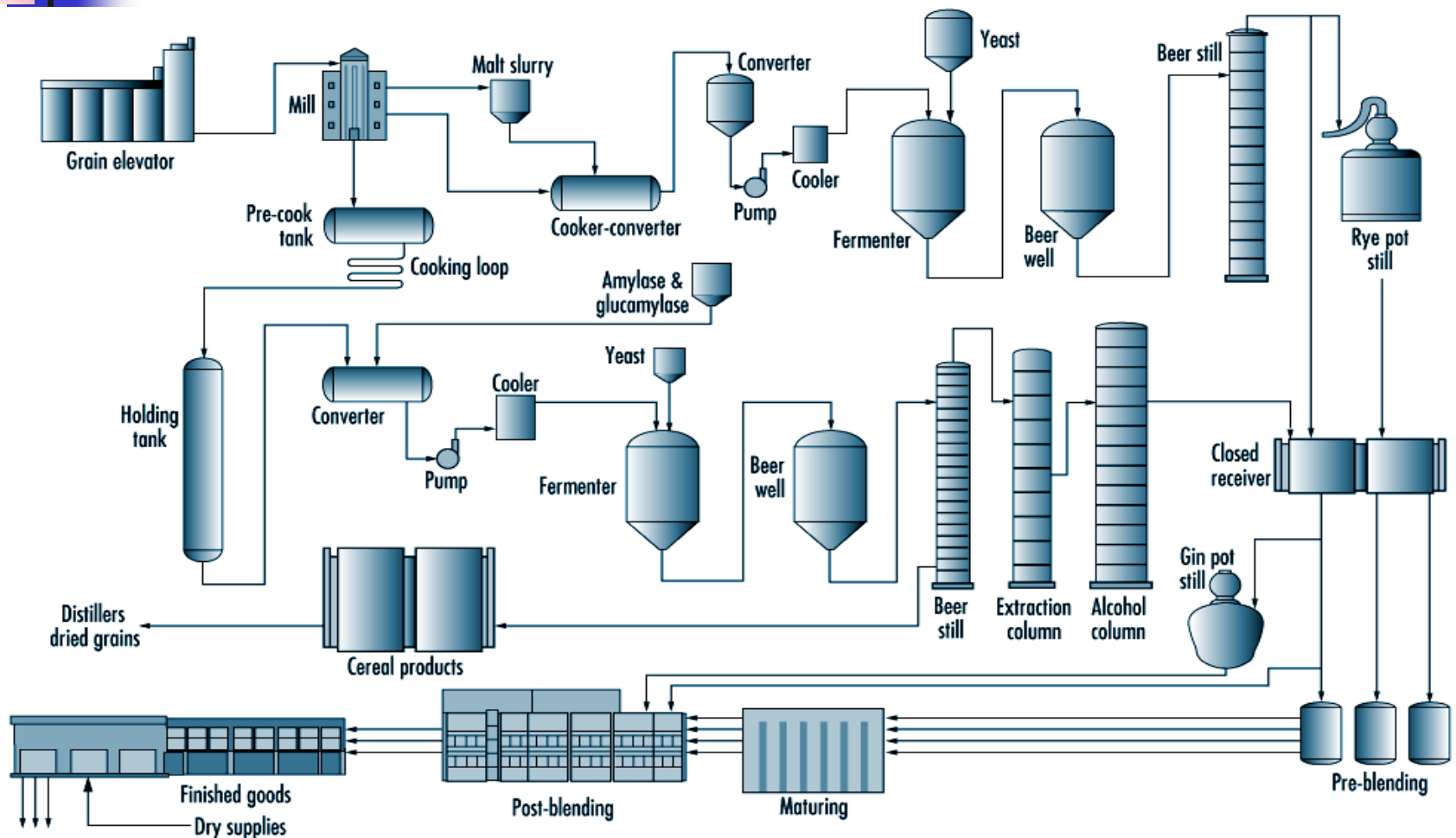




What is plant Layout?

- The layout of an operation is concerned with the **physical location** of its **transforming resources**, that is deciding **where to put** the *facilities, machines, equipment* and staff in the operation.
- For a **good plant layout** it is most essential to have **minimum movement** of **workers** and **materials** during production process.
- **Material handling engineer** and **plant layout engineer** both must **work together** in designing the layout so as to avoid future problems.

What is plant layout?

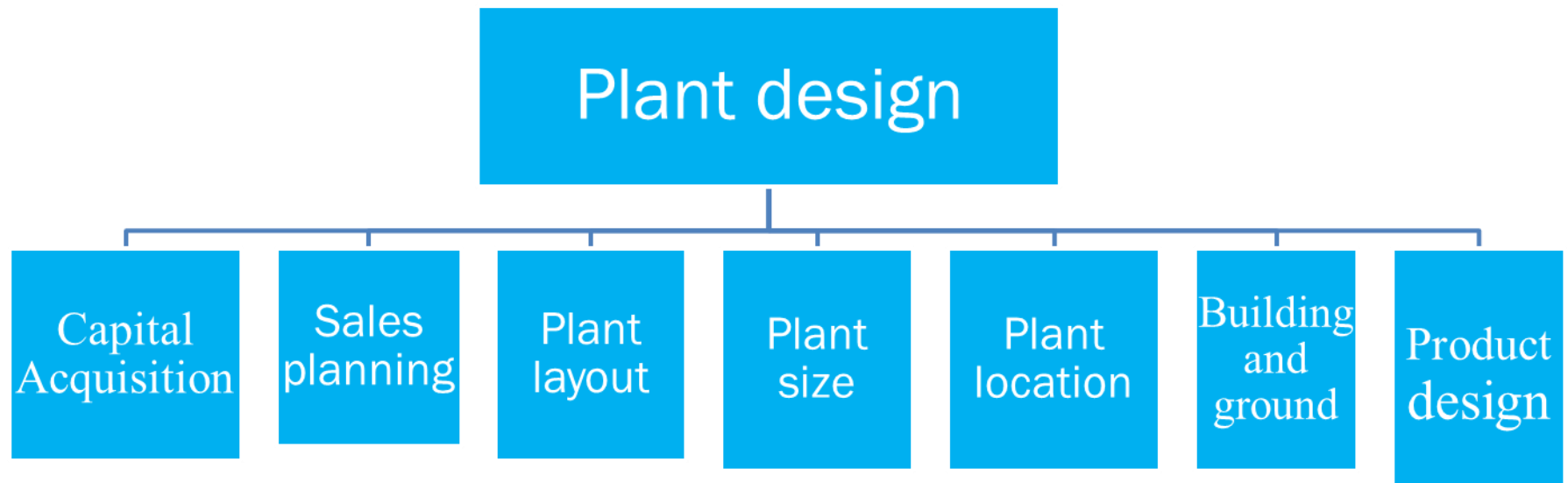


What is plant Layout?





What is plant design?

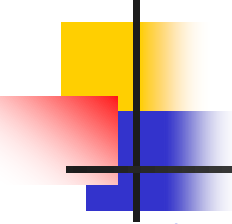




What is plant design?

Capital Acquisition

- The capital needs of an industrial concern fall into three categories;
 1. **Obtain capital** for the initial establishment of a concern
 2. Raising functions to **cover operating cost** and
 3. Changing financial structure of the going enterprise and **scanning funds for expansion**



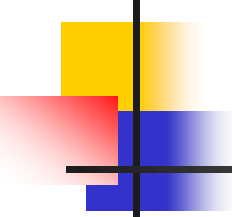
What is plant design?

Product Design

- The **nature** and **volume** of the **product** to be produced determine the **manufacturing process** to be utilized.
- The manufacturing process **specifies** the **equipment**, **machinery** and **plant** for effective plant layout.

Sales Planning for Requirements

- Market surveying to determine **sales quantity**



What is plant design?

Plant Size

- Volume of production and production-cycle time should be known to determine the plant size.

Plant Location

- Selecting a region
- Selecting a particular site within the region

Plant Layout

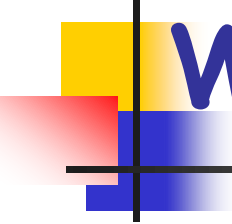
- Optimal arrangement of facilities



What is plant design?

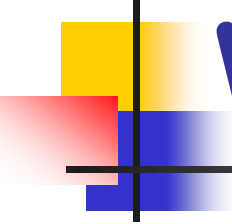
Building Type Selection

- Function;
 1. Protecting facilities
 2. Supporting production process



What types of plant Layouts?

- **Four** basic layout types consisting of:
 - Fixed-Position or Location Layout
 - Process or Functional Layout
 - Product or Line Layout
 - Cell or Group or Hybrid or Mixed Layout

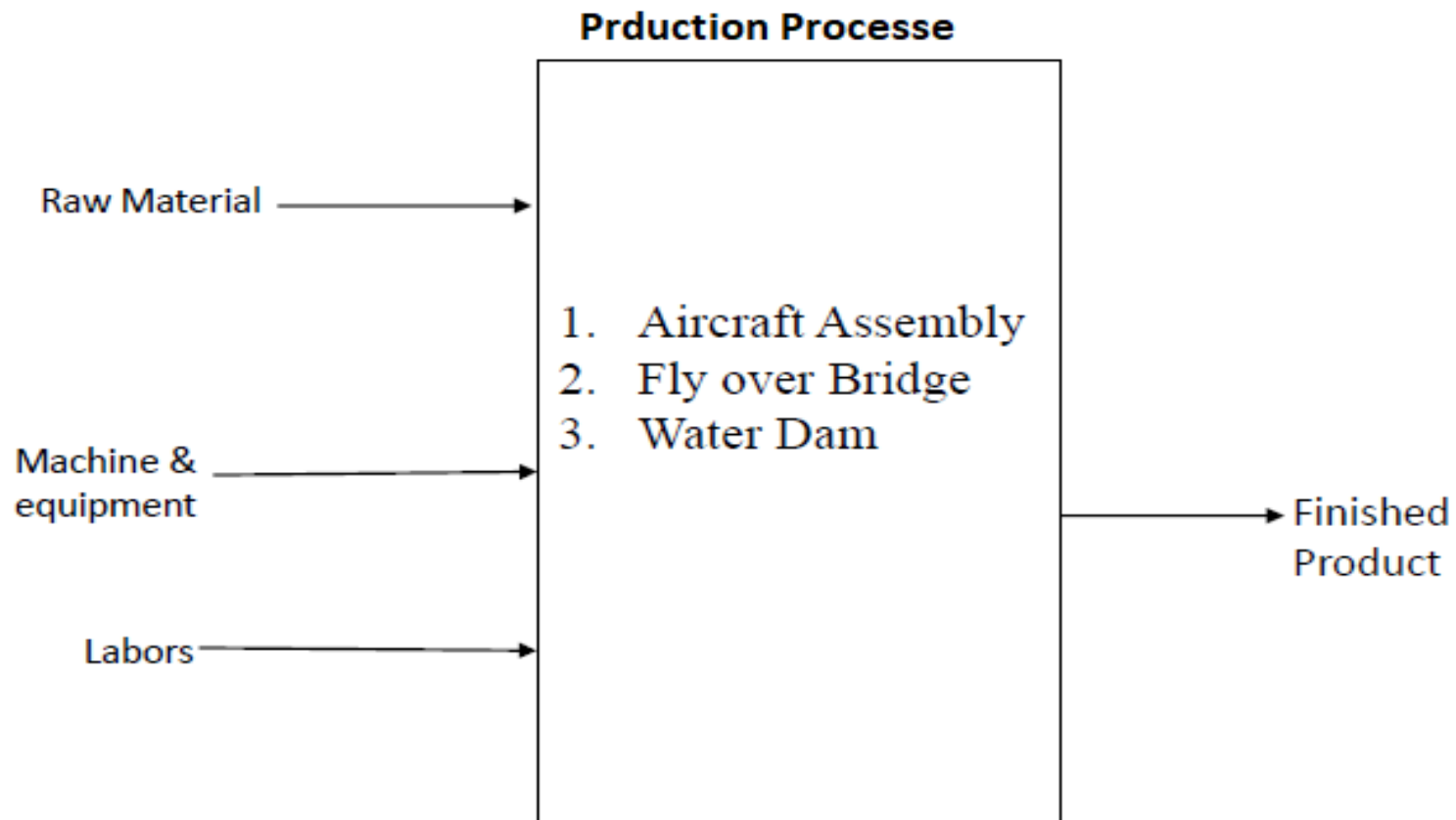


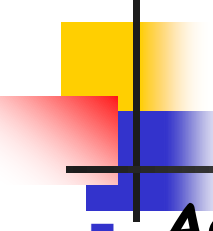
What types of plant Layouts?

Fixed-Position or Location Layout

- Resources (equipment, machinery, people etc.) who do the processing move as necessary to the product, because the product is either:
 - i. Too large
 - ii. Too delicate
- Common in industries manufacture **large size products, such as ships, aircrafts etc.**

What types of plant Layouts?





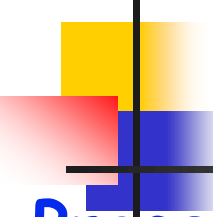
What types of plant Layouts?

- Advantages ;

- Men & machine can be used for wide variety of operations producing different products
- The investment on layout is very small
- The high cost & difficulty in transporting of bulky product are avoided

- Disadvantages;

- High cost of operation
- Very high duration of project
- Rework will be very costly

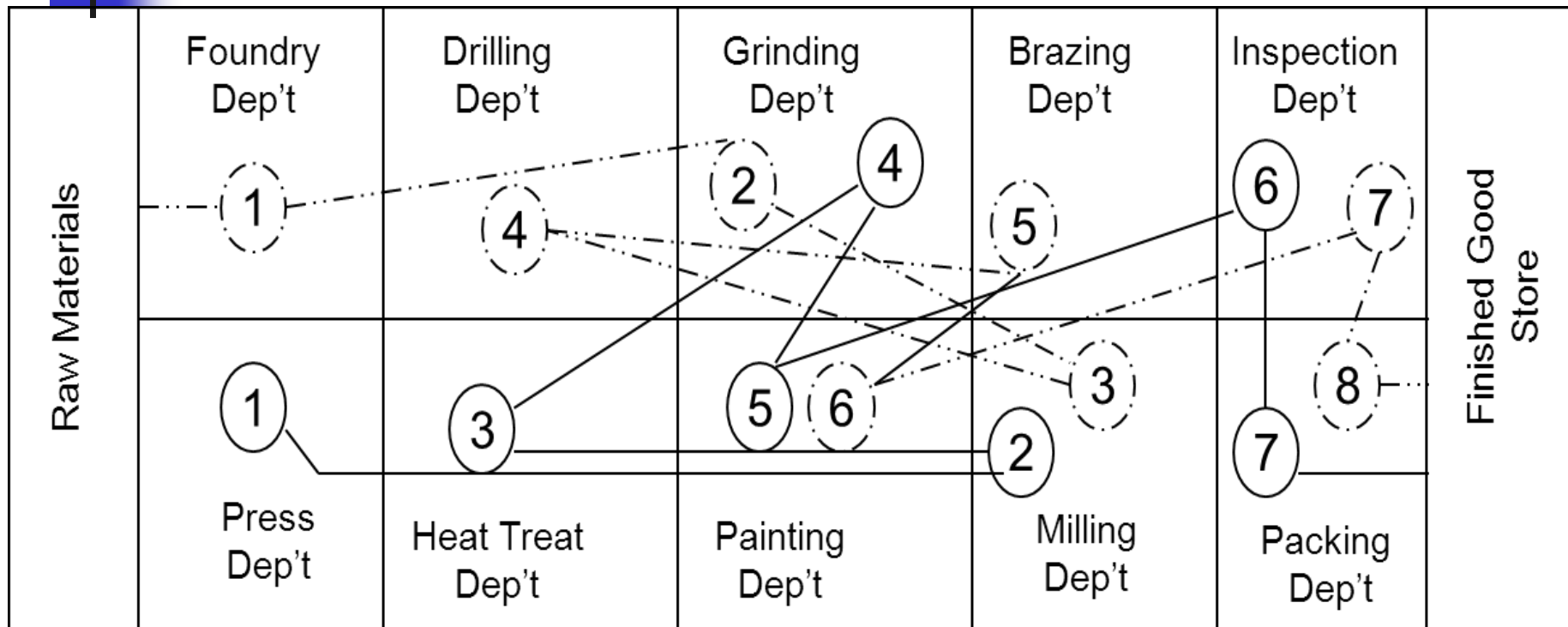


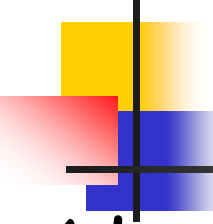
What types of plant Layouts?

Process or Functional Layout

- **Machines** of a **similar type** are arranged together at one place.
- Process layout **groups facilities** with **similar functions** together (resources of the same type).
- Used for a wide variety of product.
- **Different products** of customer have **different requirements** therefore they may take **different routes** within the process
- the flow is **very complex** with a **high space** requirements.

What types of plant Layouts?

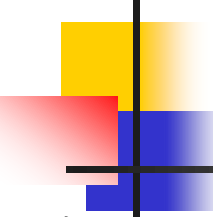




What types of plant Layouts?

Advantages;

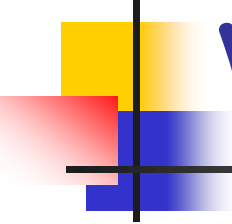
- Greater flexibility in production
- Easy to handle Machine break down by transfer to another machine
- Greater Scope for expansion
- Investment on equipment will be comparatively low
- Full utilization of equipment
- Greater incentive to operators to improve performance



What types of plant Layouts?

Disadvantages;

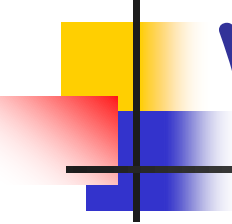
- Accumulation of work in progress
- Requires more floor space
- Difficulty in movement of material
- Production control is difficult
- High production time as WIP has to travel from place to place



What types of plant Layouts?

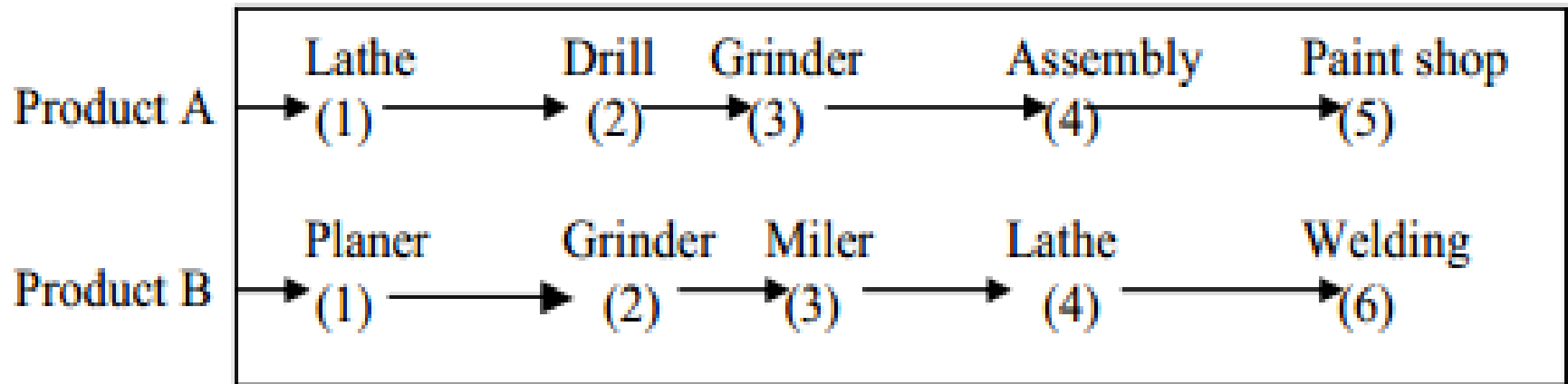
Product or Line Layout

- Machines and equipment are arranged in **one line** depending upon the **sequence of operations** required for the product.
- It is used for a system with **high production volumes** and **low variety** of products.
- Facilities are organized according to the **sequence** of the successive **manufacturing operations**.



What types of plant Layouts?

Line of production

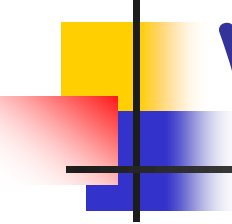




What types of plant Layouts?

Advantages ;

- Low cost of material handling, due to straight and short route and absence of backtracking.
- Smooth and uninterrupted operations
- Continuous flow of work
- Lesser investment in inventory and work in progress
- Optimum use of floor space
- Shorter processing time or quicker output
- Less congestion of work in the process
- Simple and effective inspection of work and simplified production control
- Lower cost of manufacturing per unit



What types of plant Layouts?

Disadvantages;

- High initial capital investment in special purpose machine
- Supervision is more difficult
- Breakdown of one machine will hamper the whole production process
- Lesser flexibility as specially laid out for particular product.



What types of plant Layouts?

Cell or Group or Hybrid or Mixed Layout

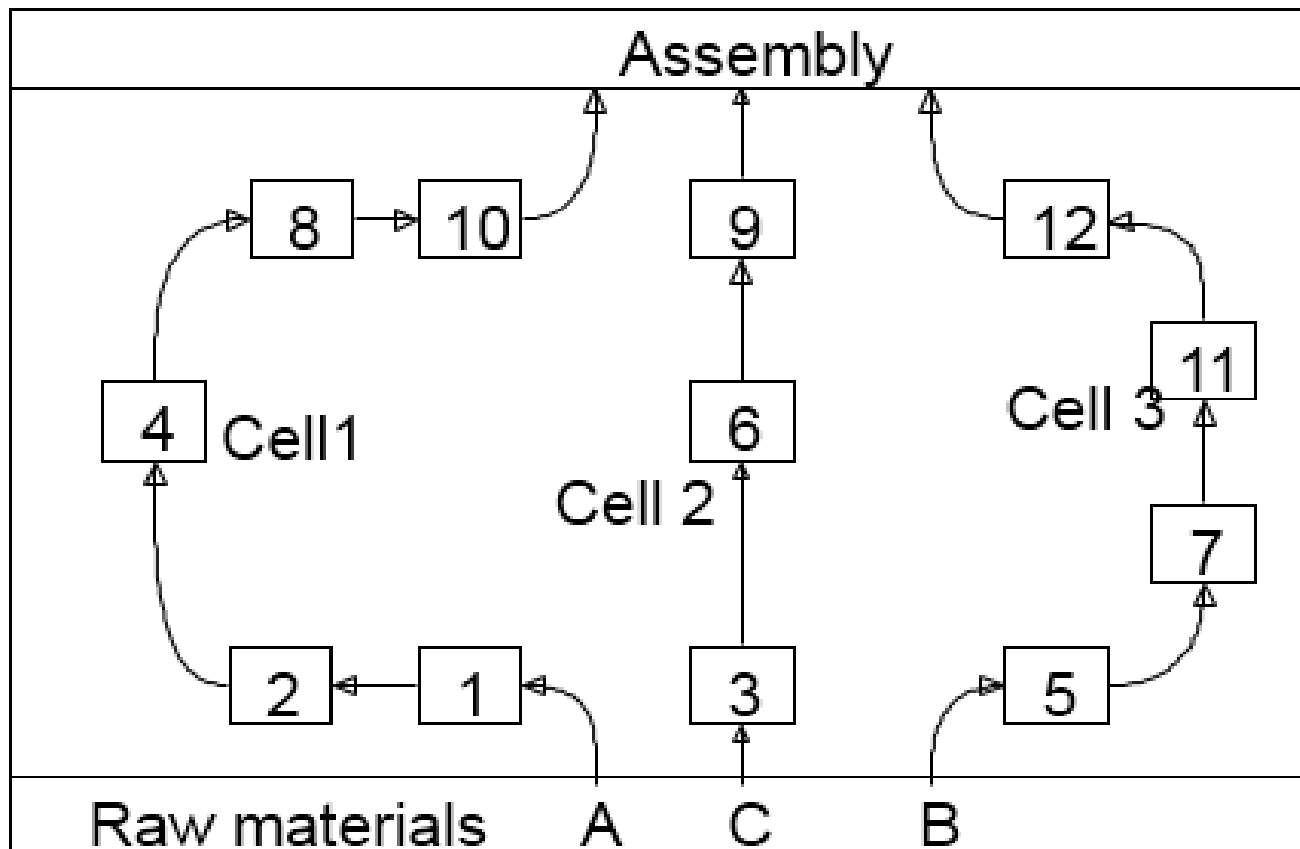
- The **arrangement** of a **facilities** or **equipment** used to make **similar parts** or **families of parts** is grouped together.
- Combine elements of both **product** & **process** layouts.
- Maintain some of the **efficiencies** of **product** and **process** layouts

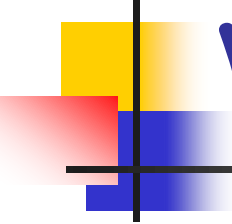
Examples:

- Group technology & manufacturing cells

What types of plant Layouts?

Each of A, B, C now visits only one area, minimizing jumping

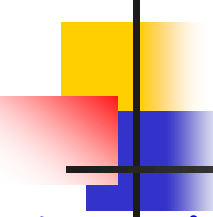




What types of plant Layouts?

Advantages;

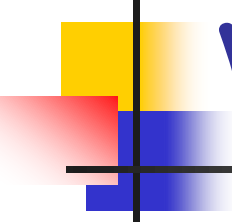
- Reduced material handling and transit time
- Reduced setup time
- Reduced work-in-process inventory
- Better use of human resources
- Better scheduling, easier to control and automate



What types of plant layouts?

Disadvantages;

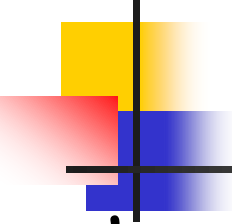
- Sometimes cells may not be formed because of **inadequate** part families.
- Some cells may have **a high volume of production** and **others very low**. This results in poorly balanced cells.
- When volume of production changes, **number of workers** are **adjusted** and **workers** are **reassigned to various cells**.
- To cope with this type of reassignments, workers must be **multi-skilled** and **cross-trained**.
- Sometimes, **machines** are **duplicated** in **different cells**. This increases capital investment.



What types of plant layouts?

Homework 3

- Compare and contrast product Vs. process layout in the view of production volume and environment, flexibility, efficiency etc.



When new plant layout need?

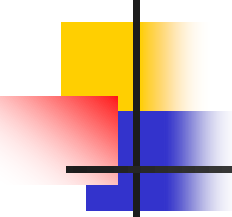
when

- start a new product,
- change the product design,
- reduce the cost;
- the market demand changes,
- the plant, the product, the building become obsolete,
- accidents occur frequently,
- the working environment is poor.



Why good plant layout?

- To ensure effective space utilization,
- To minimize the cost of material handling (internal transports),
- To foresee future developments of the plant according to a rational master plan,
- To improve workers convenience as well as safety and create job satisfaction, and
- To avoid unnecessary capital investment.



What procedure in Plant layout?

- In planning and preparing the layout, **Reed recommended** that the **following steps be taken** in his “systematic plan of attack”
 1. Analyze the product or process to be produced
 2. Determine the process required to manufacture the product
 3. Prepare layout planning charts
 4. Determine workstations
 5. Analyze storage area requirements
 6. Establish minimum aisle widths.



What procedure in Plant layout?

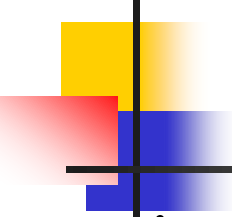
7. Establish office requirements
8. Consider personnel facilities and service
9. Survey plant service
10. Provide for future expansion



What procedure in Plant layout?

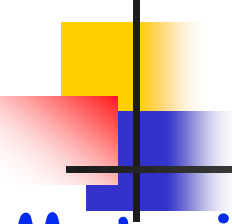
Homework 4

- *Discuss layout planning chart: in a view of operations, transportations, storage, and inspection: standard time for each work element, machine selection and balance, labor selection and balance; material handling requirements.*



What Factors Affecting Plant layout?

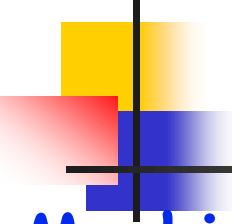
- The factors affecting plant layout can be grouped into **eight categories**:
 - Materials
 - Machinery
 - Material Handling
 - Labor
 - Waiting Time
 - Auxiliary Services
 - The building
 - Future Changes



What Factors Affecting Plant layout?

Materials

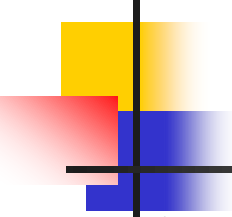
- The layout of the productive equipment will depend on the **characteristics** of the **product** to be managed at the facility, as well as the **different parts** and **materials** to work on.
- Main factors to be considered: **size**, **shape**, **volume**, **weight**, and the **physical-chemical characteristics**, since they **influence** the **manufacturing methods** and **storage** and **material handling processes**.
- The **sequence** and **order** of the **operations** will affect plant layout as well, taking into account the **variety** and **quantity** to **produce**.



What Factors Affecting Plant layout?

Machinery

- Having information about the **processes**, **machinery**, **tools** and necessary **equipment**, as well as their **use** and **requirements** is essential to design a correct layout.
- The **methods** and **time** studies to improve the processes are closely linked to the plant layout.
- Regarding machinery, we have to consider the **type**, **total available** for each type, as well as **type** and **quantity** of **tools** and **equipment**.

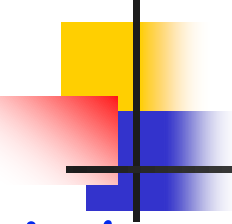


What Factors Affecting Plant layout?

- It's essential as well to know about **space required, shape, height, weight, quantity** and type of **workers required, risks for the personnel, requirements of auxiliary services, etc.**

Material Handling

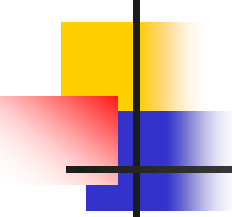
- Material handling does **not add value** to the **product**; it's just waste.
- **Minimize material handling** as well as **combining with other operations** when possible, eliminating unnecessary and costly movements.



What Factors Affecting Plant layout?

Labor

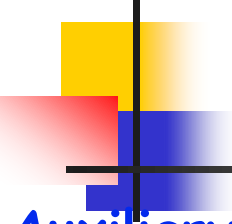
- Labor has to be **organized in the production process** (direct labor, supervision and auxiliary services).
- **Environment considerations:** employees' safety, light conditions, ventilation, temperature, noise, etc.
- **Process considerations:** personnel qualifications, flexibility, number of workers required at a given time as well as the type of work to be performed by them.



What Factors Affecting Plant layout?

Waiting Time - Stock

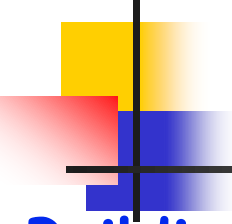
- Continuous Material Flow through the facility, **avoiding the cost of waiting time and demurrages** that happen when the flow stops.
- On the other hand, the **material waiting to flow** through the facility **not always represents a cost to avoid**; rather as **stock** sometimes it **provides safety** to protect production, improving customer service, allowing more economic batches, etc.
- It's necessary then to consider **space for the required stock** at the facility when designing the layout.
- **Resting time to cool** down or heating up...



What Factors Affecting Plant layout?

Auxiliary Services

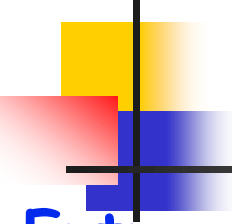
- **Related to labor:** Accessibility paths, fire protection installations, supervision, safety, etc.
- **Related to material:** quality control.
- **Related to machinery:** maintenance and electrical and water lines.
- The auxiliary services represent **around 30% of the space** at a facility.
- The **space** dedicated to **auxiliary services** is usually considered as **waste**.
- It's important to have efficient services to insure that their indirect costs have been minimized.



What Factors Affecting Plant layout?

Building

- If it has been already selected, its characteristics will be a **constraint at the moment of designing the layout**, which is different if the building has to be built.



What Factors Affecting Plant layout?

Future Changes

- One of the main objectives of plant layout is **flexibility**.
- It's important to **forecast the future changes** to **avoid** having an **inefficient** plant layout in a short term.
- Flexibility can be reached keeping the original layout as free as possible regarding fixed characteristics, **allowing** the **adjustment** to **emergencies** and **variations** of the normal process activities.
- Possible **future extensions** of the **facility** must be taken into account, as well as the feasibility of production during re-layout.



What Factors Affecting Plant location?

Site Selection

- Location decisions are **strategic**, **long-term** and **non repetitive** in nature.
- Without sound and careful location planning in the beginning itself, the new facility may create **continuous operating problems** in the future.

Plant location is important because of the following:

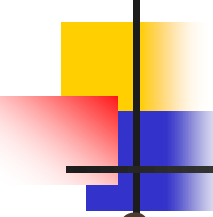
1. Location influences plant **layout facilities** needed
2. Location influences **capital investment** and **operating costs**



What Factors Affecting Plant location?

Factors considered in selecting region for factory location;

1. Availability of raw materials
2. Proximity to market
3. Transport facilities
4. Availability of cheap and efficient labor
5. Availability of power and fuel
6. Climatic and atmospheric condition
7. Availability of water
8. Availability of capital

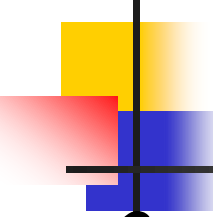


What Factors Affecting Plant location?

9. Social and Recreational facilities
10. Business and commercial facilities
11. Existence of related industries
12. Other factors like taxes, fire protection facilities, post, telephone facilities

Factors considered in selecting particular site for factory location;

1. Community facilities
 - Schools, hospitals, housing, banking, communications etc.



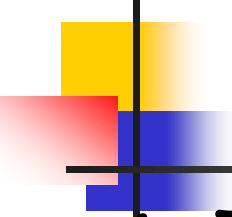
What Factors Affecting Plant location?

2. Community attitude

- Expecting **employment opportunities** to the local people
- Resistance from local population for **polluting** or adversely **affecting industries**

3. Topography

- Subsoil condition for building foundation
- Cost of **leveling** and **developing** the **area laying** the water supply lines, electricity, drainage and sewage should remain within reasonable limits.



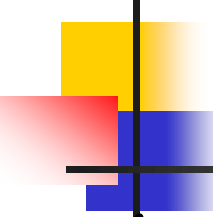
What Factors Affecting Plant location?

4. Transportation Facilities

- The plant site should be **accessible** by **road** and/or **rail**, so that the transportation cost is minimum and movement is easy and quick.

5. Water disposal

- The plant should be positional so that prevailing **winds carryout fumes away** from populated areas, and that waste may be disposed off properly at **reasonable expense**.



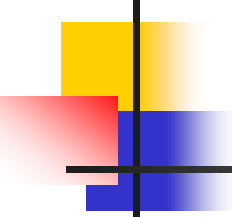
What Factors Affecting Plant location?

6. Ecology and Pollution

- There may be **restriction** imposed **by** local **government**

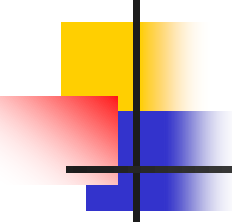
7. Size of Land

- The plot of **land must be sufficient** in size to meet the needs of the **proposed plant** including parking areas and other facilities and space for **future expansion**.



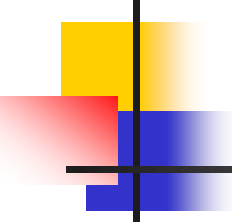
What Principles of Plant Layout?

- The principles should considered by **plant engineer** and **materials handling engineer** while designing a plant layout are;
 1. Principles of overall integration(**sense of unity**)
 2. Principles of minimum distance(**minimum movement of materials, machines and other resources**)
 3. Principles of satisfaction and safety
 4. Principles of cubic space(**floor * height**)
 5. Principles of Flow
 6. Principles of Flexibility(**demand change**)
 7. Principles of Expansion
 8. Principles of Versatility (**change in technology**)
 9. Principles of orderliness(**Uniformity**)



What Ergonomics and Industrial Safety?

- The term ergonomics is derived from the Greek, *ergon* which means work, *nomos* is science.
- Ergonomics is the study of the **relationship** between **people**, their **work tools**, their **work place**, and the **tasks** they perform.
- Ergonomics is used to **design** an **environment** (layout, work methods, equipment, noise, etc.) which is **compatible with each individual's physical and behavioral characteristics**.



What Ergonomics and Industrial Safety?

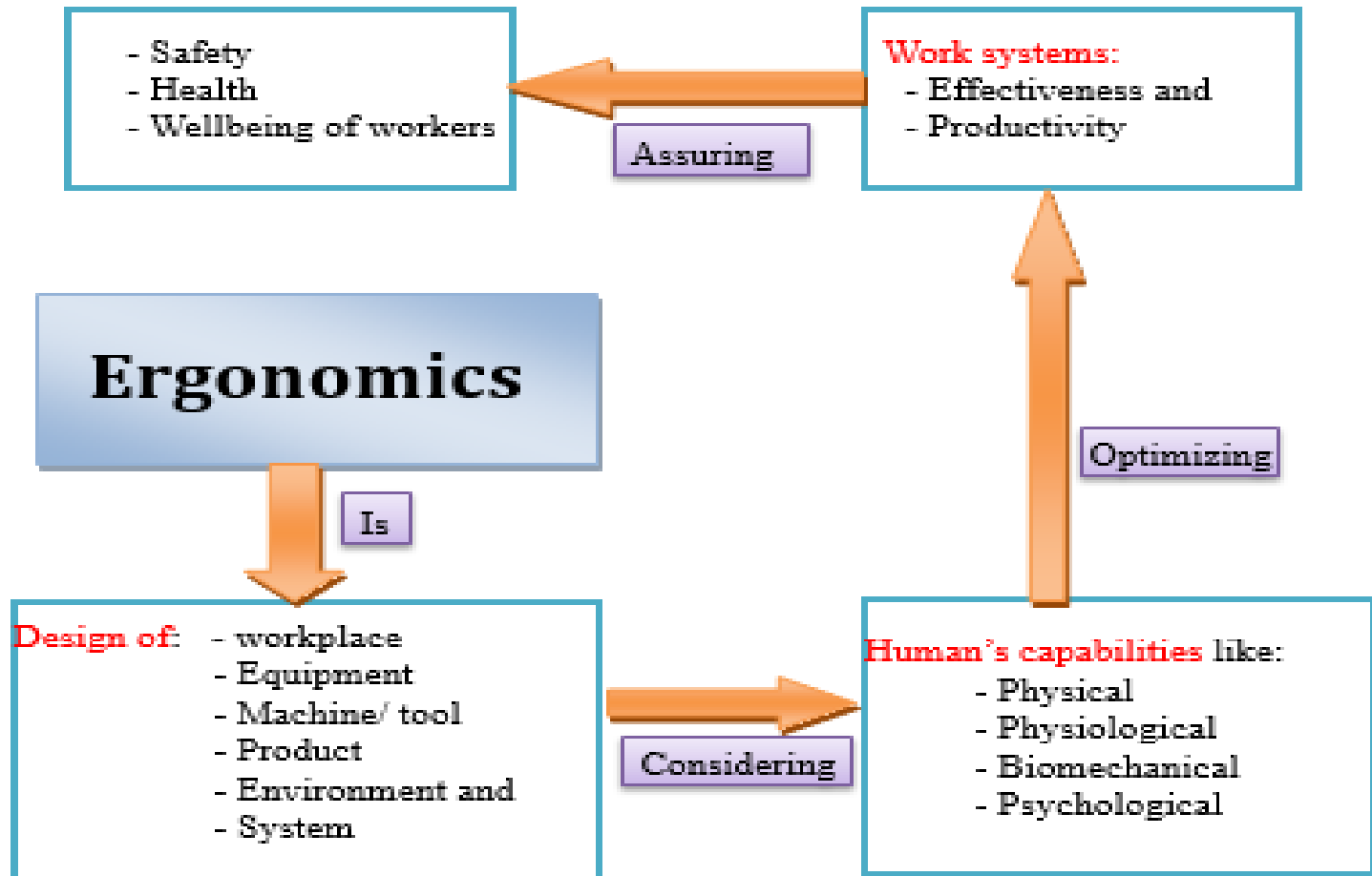
- Ergonomics is an interdisciplinary activity based on engineering, psychology, anatomy, physiology and organizational studies.
- Its aims are to **improve efficiency, safety and operator well-being**.
- Ergonomics is concerned with the **interfaces and interactions between the human operator(s) and the other components** and with the effects of these interaction on system performance.

What Ergonomics and Industrial Safety?

- Ergonomics is the **science** of **designing the job to fit the worker**, rather than physically **forcing the worker's body to fit the job**.
- What do you say about the **fitness** of this **person** and his **work**?

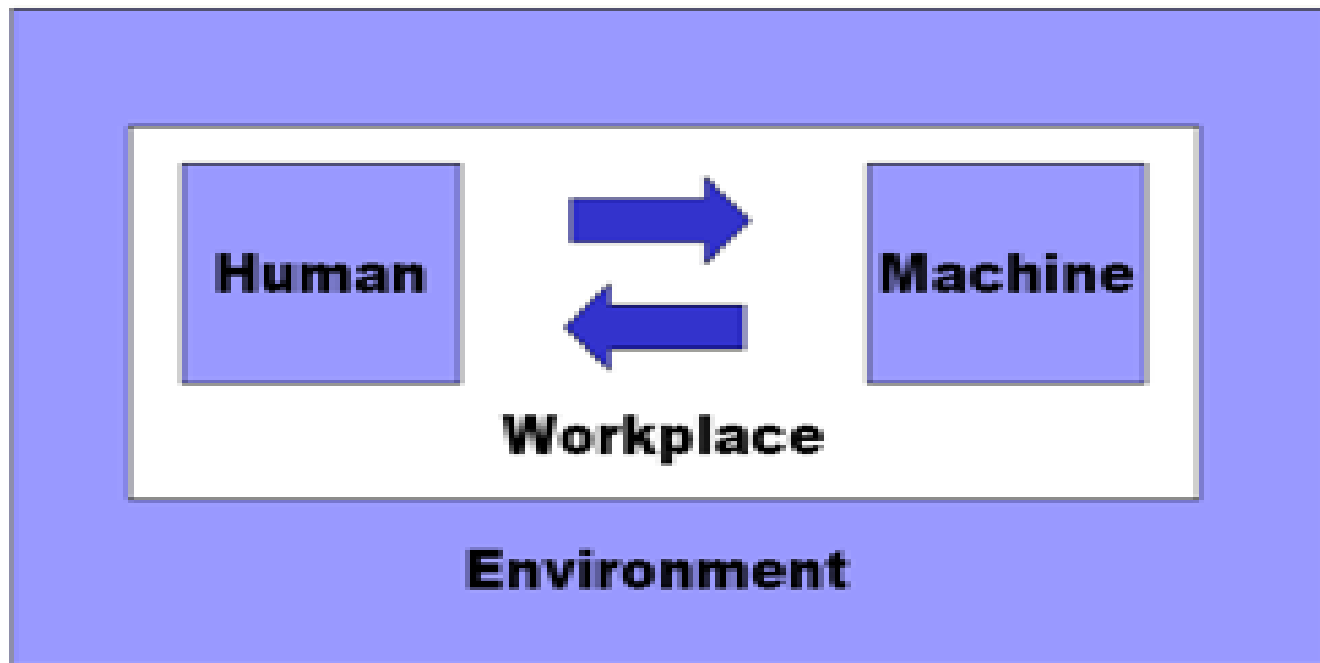


What Ergonomics and Industrial Safety?



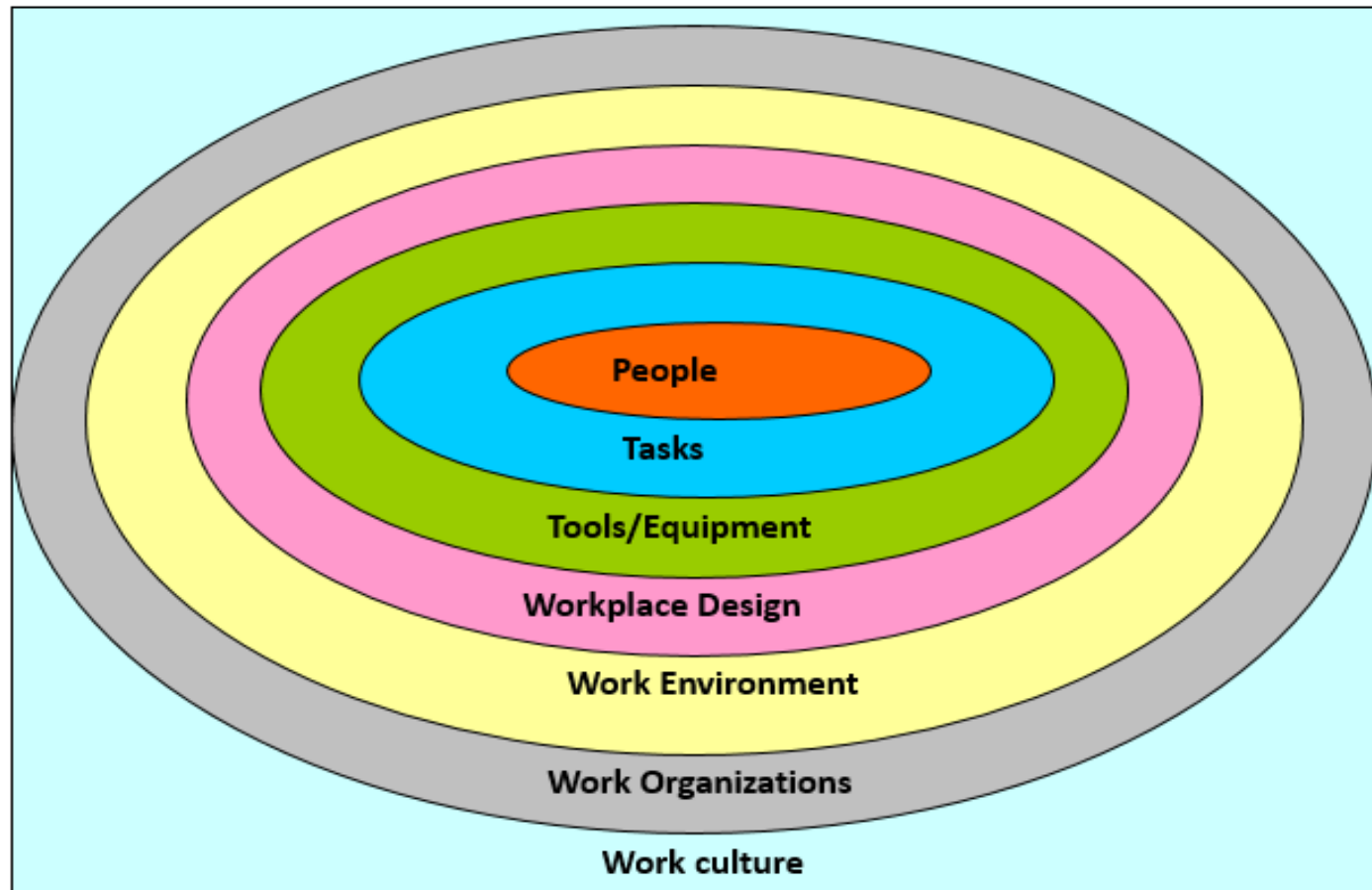
What Ergonomics and Industrial Safety?

Concerned with the study of human interaction with man-made objects and processes, and with the natural or man-made environment

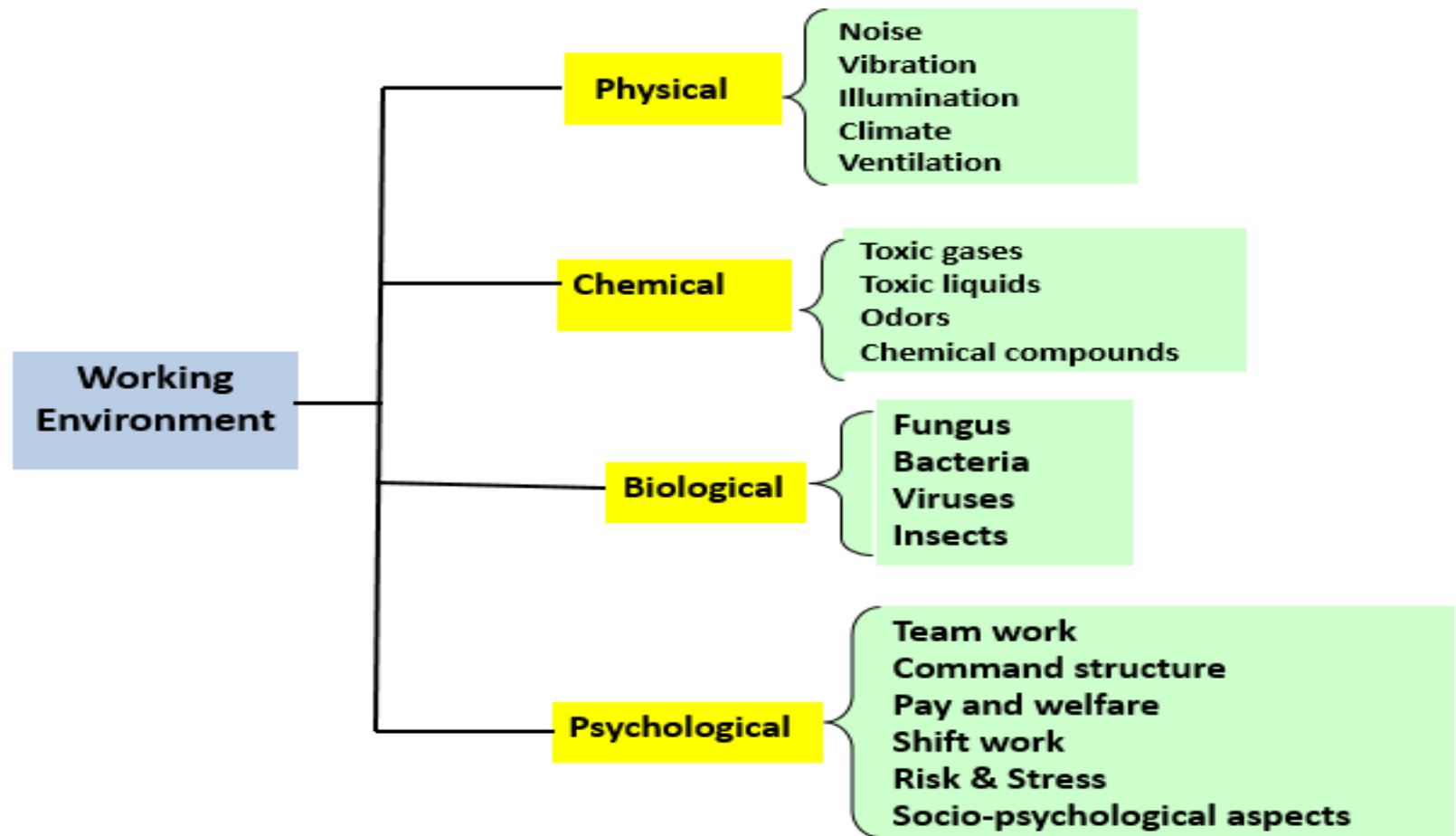


What Ergonomics and Industrial Safety?

Ergonomics system Dimensions



What Ergonomics and Industrial Safety?



What Ergonomics at work?



Risk of injury - Heavy lifting



Cart reduces risk

What Ergonomics at work?



What Ergonomics at work?

Awkward postures happen when the work is:



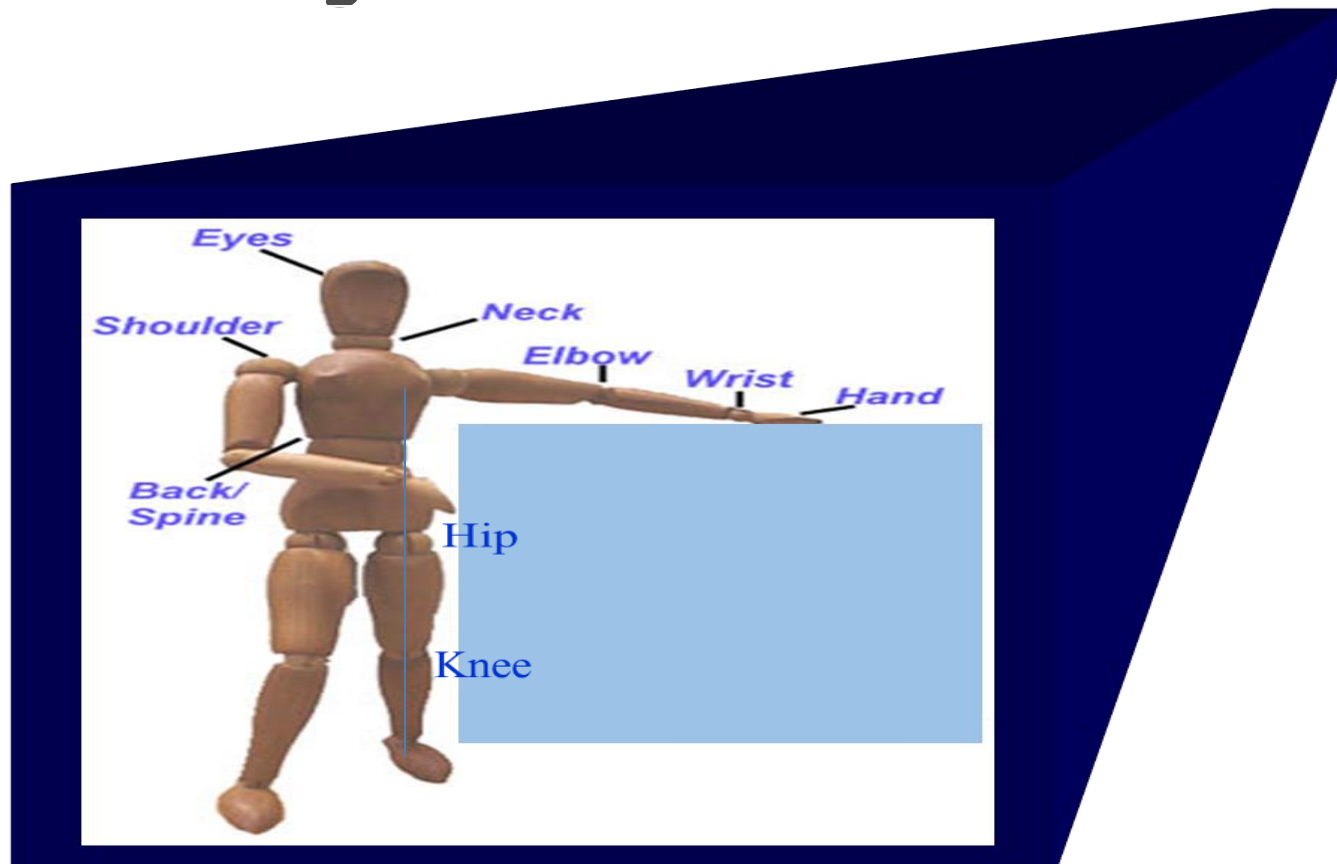
What Ergonomics at work?

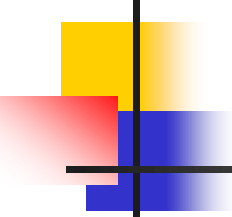
Ergonomics at Work - Reducing heavy lifting
Mechanical assistance



What Ergonomics at work?

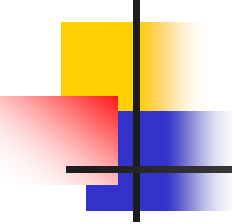
Ergonomic Stress Areas





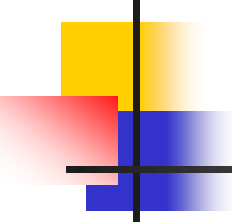
What Work-related Musculo-Skeletal Disorders (WMSDs)?

- **WMSDs** injuries are also **known as**; Cumulative Trauma Disorders (CTDs), Repetitive Strain Injuries (RSIs) and Musculoskeletal Disorders (MSDs)
- Work-related MSDs **occur** when the **physical capabilities** of the **worker** do **not match** the **physical requirements** of the **job**.
- WMSDs affect the soft tissues of the body -the muscles, tendons that connect muscles to bones, ligaments that connect bone to bone, nerves, blood vessels, pretty much every part of your body that's not a bone or internal organ.



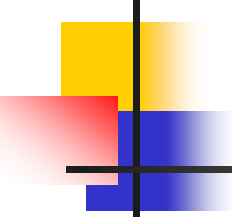
What Common causes of WMSDs?

- Repetitive and/or prolonged activities
- Awkward postures/positions for an extended time
- Static postures
- Vibration
- High/low Temperatures for an extended time
- Forceful exertions



What Symptoms of WMSDs?

- Burning
- Welling
- Change in color
- Tightness, loss of flexibility
- Discomfort
- Pain
- Numbness
- Tingling



How Control of WMSDs hazards?

- According to the Bureau of Labor Statistics, medical expenses and worker's compensation costs will continue to rise unless companies make a conscientious effort to implement ergonomic solutions.
- Employers can **prevent hazards** by **properly designing the job** or **work station** and selecting the **appropriate tools** or equipment for that job.
- Based on information from the job analysis, an employer can **establish procedures** to correct or **control risk factors** by **using**: **Administrative controls**, **Work practice controls** and **Engineering controls**.



How Control of WMSDs hazards?

Administrative controls

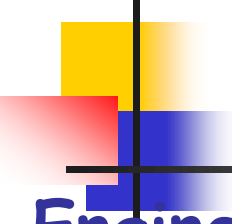
- Administrative controls are **modifications in the way work** in a job is scheduled that **decrease** the duration, **frequency**, or **magnitude of exposure** to ergonomic risk factors.
- Administrative controls of ergonomics hazards include;
 - Employee rotation/job task expansion
 - Physical adjustments to the work pace
 - Redesign of work methods
 - Alternative tasks and Breaks



How Control of WMSDs hazards?

Work practice controls

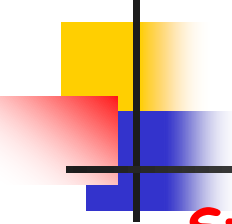
- It is control that **reduce** the **likelihood** of **exposure to MSD hazards** through alteration of the manner in which a job or physical work activities are performed.
 - Safe & proper work techniques & procedures: work techniques includes proper positions and angles when sitting at your computer station, standing positions to performing tasks.
 - Training: recognition of hazards and work techniques that can reduce exposure or ease task demands and burdens.
 - Physical conditioning period: it is for new or reassigned employees to learn the work techniques and procedures.



How Control of WMSDs hazards?

Engineering controls

- Engineering controls are the **physical changes to jobs** that **control exposure to WMSDs** hazards.
- It **acts on the source of the hazard** and **control employee exposure to the hazard** without relying on the employee to take self-protective action or intervention.
- Appropriate engineering controls, such as work station, tool, Facilities and equipment design or redesign.
- The objective is to **Fit the workstation to the employee** and **Reduce awkward positions** by using **Standard Way** and **Innovative Way**.



How Control of WMSDs hazards?

Standard Way

- Adjustable workstation
- Adjustable chair
- Foot rests
- Adjustable monitor
- Document holder

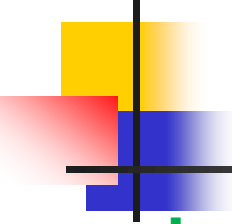
Innovative Way

- Cut legs off
- Add blocks
- Build foot rest
- Thick book
- Build platform



How Control of WMSDs hazards?

- Principles of using the **correct tool** for the **correct task** is applying to all types of hand tools in shop, kitchen, garden etc.
 - Use of Force or grip-strength
 - Longer/shorter and thicker/thinner handles
 - Repetitive motion
 - Ratcheting mechanism or gears
 - Power tools: Electric stapler, Electric knife, Spring-loaded returns
 - Forceful exertions:
 - Soft-touch keyboards/buttons,
 - Lifting devices



How Control of WMSDs hazards?

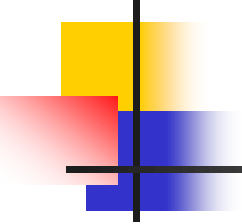
- Awkward positions:
 - Bent or curved handles,
 - Extensions or add-ons,
 - Headphones,
 - Support equipment overhead,
 - Step stool
- Static positions
 - Anti-fatigue mats
- Vibration
 - Anti-vibration materials
 - Anti-vibration mounts/handles
 - External support
 - Anti-vibration gloves

How Control of WMSDs hazards?

- **Facilities** or **environmental** conditions can affect employees.
 - lighting, temperature, and noise.

Awkward positions-Could be reaching for items. Keep supplies and frequently used tools within a comfortable reach.





Thank you

