Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. 1 A) Attempt any three

a) Define factor of safety. List the factors governing its selection.

FACTOR OF SAFETY

The factor of safety is defined as a ratio of the maximum load carrying capability of the component to the design loading. Type of loads can be static, impact, fatigue, etc. The purpose of using a safety factor is to safeguard the design against unexpectedly high loads, material defects and process defects. It results the probability of failure. This is also called the factor of uncertainty on the part of material, process, design and service performance of a component.

Lower factors of safety are required if high quality and consistency of materials, manufacturing, maintenance and inspection are ensured. Good control or knowledge of the actual loads and environment and highly reliable analysis and/or experimental data is required. For example, in commercial airplane business has extremely rigorous control over airplane structures and systems from fabrication and assembly through inspection and maintenance. The environmental effects and maximum loads that airplanes experience are also well understood. Extensive fatigue and static testing is conducted on components and systems. The criteria of using particular value of factor of safety as low as 1.3 in aircraft industry to as high as 5 in machine tool design depends on the estimation of uncertainties as well as probability of failure. In some instances like in pressure vessels the factor of safety is mandated by design code and standards. More often the factor of safety is decided by experience of similar designs. In mechanical engineering practice typically factor of safety ranges from 1.3 to 5. Factor of safety is based on number of factors like material strength, nature of load, misuse, complex state of stress, environment, etc.

factors governing its selection

1. *Material strength basis:*
   Brittle materials—use ultimate strength
   Ductile materials—use yield strength
2. *Nature of load basis:*
   Static—applied slowly and gradually
   Repeated—fatigue failure may occur at stresses lower than static load failure
   Impact—high initial stresses develop
3. *Possible misuse:* Designer must consider any reasonable foreseeable use and misuse of the component
4. *Complexity of stress analysis:* The actual stress in a part is not always known
5. *Environment:* Temperature, weather, radiation, chemical, etc.

02 Marks for Definition 02 Marks for any 4 Factors

b) Differentiate between cutting tool and machine tools.

Cutting Tool	Machine Tool
• Cutting tool is any tool that is used to remove material from the work piece by means of shear force.	• Machine tool is an assembly of many machine parts to convert energy from one form to another.
• Cutting tool is a component of machine tool	• Machine tool represents itself such as milling, lathe machine.
• Cutting tools are used for cutting the	• Machine tools employ some sort of tool

workpiece.	that does the cutting or shaping.
• Cutting tool is portable.	• Machine tool is a non portable power operated.

01 Mark to each point

c) State the different requirement of machine tool structures

Machine tool structures must satisfy the following requirements:

1. All important mating surfaces of the structures should be machined with a high degree of accuracy to provide the desired geometrical accuracy.
2. The initial geometrical accuracy of the structures should be maintained during the whole service life of the machine tool.
3. The shapes and sizes of the structures should not only provide safe operation and maintenance of the machine tool but also ensure that working stresses and deformations do not exceed specific limits. It should be noted that the stresses and deformations are due to mechanical as well as thermal loading.

The design features that provide for ease of manufacture, maintenance, etc., are peculiar to each structure and will, therefore, be discussed separately for different structures. However, there are two common features which are fundamental to the satisfactory fulfillment of above requirements for all structures. These are:

1. Proper selection of material.
2. High static and dynamic stiffness.

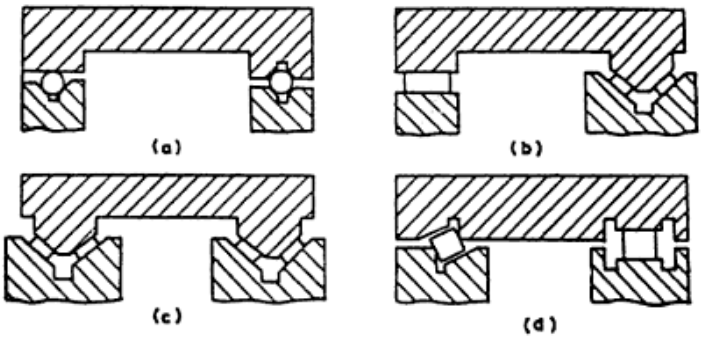
Any 04 requirements 04 Marks

d) What is closed and open guide ways? Draw the sketch of any one type.

In anti-friction ways intermediate rolling members (balls or rollers) are inserted between the sliding surfaces, thus changing the nature of friction from sliding to rolling. They have the following positive features:

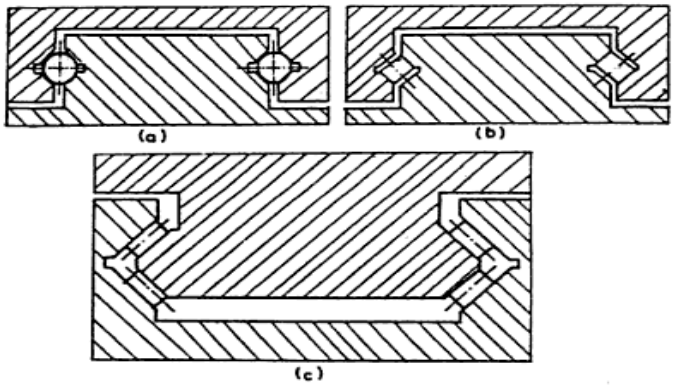
1. low friction as compared to slideways,
2. uniformity of motion even at slow speeds due to virtual absence of the stick-slip phenomenon,
3. high stiffness if the rolling members are preloaded, and
4. possibility of using high velocities of motion.

Anti-friction guideways employ the same shapes as slideways. These shapes can be obtained by an appropriate surface profile or by changing the profile and location of the rolling elements. Anti-friction ways can be open or closed type. A few examples of open ways are shown in Fig. It may be noted that the V profiles of Fig. c and d have been obtained by different methods. Open-type anti-friction ways are employed only when the dead weight of the moving member constitutes the major load which does not change appreciably during the cutting operation.



Open-type anti-friction ways

Closed-type anti-friction guideways are used when working loads are relatively large and guideways are required to have high stiffness. Higher stiffness is achieved through preloading of rolling members. As a matter of fact horizontal rolling members automatically experience some preloading due to the weight of the moving member.



Closed-type anti-friction ways

Explanation 02 Marks Sketch (Any One Type) 02 Marks

B) Attempt any one

i) Define stress concentration factor. State its importance in design.

Stress concentration factor:-

When there are any irregularities may be due to the presence of holes, keyways, slots, shoulder, or even any inclusions or impurities in the material. V or there is any change in the cross section, the distribution of stress does not remain uniform throughout and the basic relations unable to describe the state of stress at those points. The actual state of stress at a point in a mechanical part is obtained from the product of the nominal stress and the stress concentration factor at that point. Hence, stress concentration factor can be defined as the ratio of the maximum stress to the nominal stress. The stress concentration factor k_t is given by

$$k_t = \frac{\text{Actual stress at a point P}}{\text{Nominal stress at a point P}}$$

Stress concentration is highly localized effect. The variation in the stress distribution exists only in a very small region in the vicinity of the discontinuity. This region is known as *zone* or *area of stress concentration*.

Importance in design

The stress raisers have a very little effect on the material with internal irregularities such as gray cast iron, regardless of type of loading. For static loading the stress concentration factor is important for those materials which behave as brittle manner. In case of ductile material the load applied to the member causes yielding at the discontinuity. The relieve of the stresses occurs due to yielding of the material at the area of stress raiser or discontinuity. Engineering materials having some ductility and behave in a ductile manner, it is not necessary to use a stress concentration factor at all. Stress concentration must be considered when the part is made of brittle materials or when they are subjected to fatigue loading. Even under these conditions if a material is insensitive to notch or irregularities, or are not so sensitive to the existence of the notches or discontinuities, full value of the stress concentration factor need not be used. For those materials, it is necessary to use a reduced value of stress concentration factor, k_t.

03 Marks for definition 03 for Importance

ii) List the factors affecting stiffness of machine tool structure. Give the methods to improve it.

Factors affecting stiffness of machine tool structure:

1. Bending stiffness is affected most by apertures in walls, perpendicular to the plane of bending.

2. Apertures of equal dimensions have less effect on the torsional stiffness of a structure with wider walls.
3. From among the aperture dimensions, its width has maximum effect on stiffness.
4. If there are a number of apertures in a structure the effect of those apertures that are considerably smaller than the dominant one can be neglected.
5. If there are two apertures of more or less the same size in opposite walls of a structure, the reduction coefficient k is multiplied by another coefficient $k' = 0.7 - 0.95$; the larger value of $k' = 0.95$ being used for apertures in wide walls when $b_0 = 0.5B$ and $t_0 = (0.3 - 0.5)L$.

Methods to improve it:

The stiffness of structures can be improved by using ribs and stiffeners. However, it should be noted that the effect of ribs and stiffeners depends to a large extent upon how they are arranged.

The stiffness of open structures, such as lathe beds, which consist of vertical shears connected by ribs also depends to a great extent upon the arrangement of stiffeners.

The stiffness of structures can also be improved by providing a proper arrangement of fastening bolts.

It is evident that by arranging the fastening bolts uniformly the stiffness can be improved by 10–20%. By additionally providing flange stiffeners, the column stiffness can be increased by almost 50%. Rigidity of the machine tool as a whole depends upon the rigidity with which various units are clamped. It should be kept in mind that joints between various structural elements, e.g., joints between the head stock and tail stock of a lathe with the bed, the base plate of a drilling machine with its column, etc., should be made as rigid as possible.

03 Marks for Factors 03 for Methods of Improvement

Q. 2 Attempt any four:

i) Write general procedure of machine tool design.

The general procedure of machine tool design is as follows:

1. Problem definition:

The first step in the design procedure is to define the problem in a clear and simple statement of the functional needs. The manufacturing engineer usually provides the tool designer with the problem. He has determined a need for necessary tools and assigns the job to the tool designer.

2. Need Analysis:

The needs analysis, sometimes called the predesign analysis, pinpoints the problem in terms of functional need. The problem is analyzed by asking who, why, how, when, what, and where questions about the functional requirements of the problem statement.

3. Research of design:

In the research of the design, information and data based on the needs analysis are gathered. This information will include such items as the dimensions of the part to be held or produced, the kind of material from which the part is made, the tolerances of the part, the dimensions of the machine, the limitations of the machine, and the amount of tonnage to blank the part

4. Tentative Design solution:

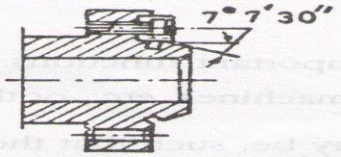
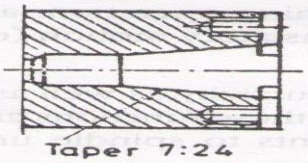
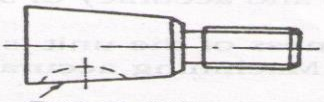
The research and sketches should be combined into one or two tentative design solutions, which may consist of rough working drawings showing a side and top view and perhaps an end view if needed. They may or may not be to scale, depending upon the judgment of the tool designer. An isometric or perspective sketch may be made if desired, although the tool designer is not as concerned with the visual aspects of the design as the industrial designer is. The tentative design solutions will be evaluated, the best selected and reworked, and the final design decided upon.

5. The Finished design:

The finished design may not be the actual finished product, for even in the final stages of drawing changes and additions may be necessary. However, an accurate drawing must be completed before the toolmaker is able to begin construction. The drawing will probably consist of a three-view (or more) orthographic drawing, which will be drawn to scale according to the tool-drawing procedures established by the company.

Any 04 points 04 Marks

ii) State the types of spindle and its requirement.

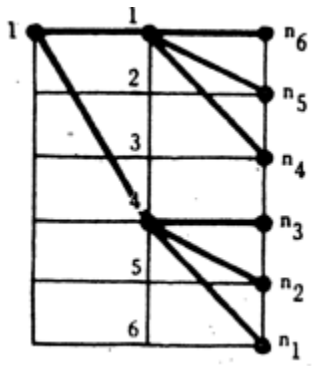
S. No.	Figure	Application
1.		Lathes, turrets, single spindle automatic and semi-automatic lathes, etc.
2.		Milling machines
3.		Drilling and boring machines
4.		Grinding machines

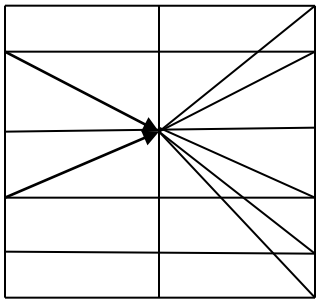
Requirements of Spindles:

1. Running accuracy.
2. Axial load carrying capacity.
3. Thermal stability.
4. High static and dynamic stiffness.
5. Axial freedom for thermal expansion.
6. High speed of operation.

Types ½ Mark each and 02 marks to any 04 requirements

iii) Draw any structure diagram for 1x2x3 and 3x1x2.





Ray Diagram for (1X2X3) Ray Diagram for (3X1X2)

02 Marks to each Sketch

iv) Explain significance of Ray diagrams.

Ray diagram displays exact location of speed and then a ray diagram helps in calculating gear ratios. Various ray diagrams can result from a single structure diagram and these diagrams can be classified as unilateral, bilateral and skewed.

Structure diagram displays the pattern of connection of speeds at the input, output and intermediate stages without indicating the actual speeds of intermediate points and gear-ratios. Structure diagrams can be 'opened' or 'crossed' type. It is important that while drawing such diagram arrows must be drawn parallel when repeated for another set in the same stage to maintain same gear ratio.

Relevant explanation 04 Marks

v) State the importance of ergonomics in machine tool design.

Progress in production technology is governed by advances in machine tools and manufacturing techniques. The advances in machine tool manufacturing techniques take into account various aspects such as, augmenting higher productivity, reduction in labour cost, improving labour conditions, reducing physical labour, need for automation, provision of a clean environment, occupational safety, and all other factors connected with the man-machine interface. Man-machine system consideration is of great importance and value to modern industries. Industries are now realising the human limitations to processes and controls, and are engaged in designing systems based on ergonomic principles. Thus, ergonomics attempts to match successfully the machine to man, so that the whole system works effectively. Before the product is designed, it is essential to have a good knowledge of the working of the various operational elements. Since, in ergonomics the human operator is regarded as an integral part of the system, an understanding of the physical and mental ability of human beings constitutes an important part of the work.

For evaluating the overall safety of a product, it should be subjected to very stringent tests which go far beyond the normally encountered accidents. Even some seemingly unreasonable limits should be set so that the evaluation proves that the product is absolutely safe. The results of such a safety audit should constitute the basis for designing safety features into the product. The product must be designed for forseeable use, not solely for intended use. Once the functional aspects of the product are designed, a subjective analysis should be undertaken to articulate the type of use and misuse the product can be subjected to in the hands of all who may come in contact with it.

Relevant explanation 04 Marks

Q 3 Attempt any TWO of the following

a)

i) **Materials used in Machine Tool structure and properties**:-

The materials used are :- The commonly used materials **are cast iron and steel**. The cast iron structures were almost exclusively used in machine tools till a decade or so ago, but lately welded steel structures are finding wider applications due to advances in welding technology.

02 Materials 02 marks

Material properties:- The material properties of relevance are:-

1 steel has higher strength under static and dynamic load.

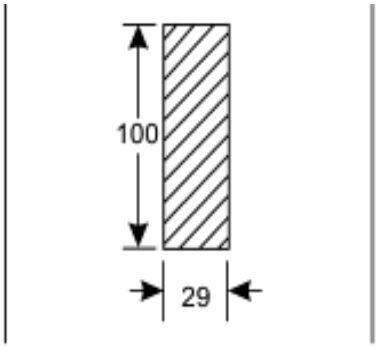
2 The unit rigidity of steel under tensile, torsional, and bending loads is higher.

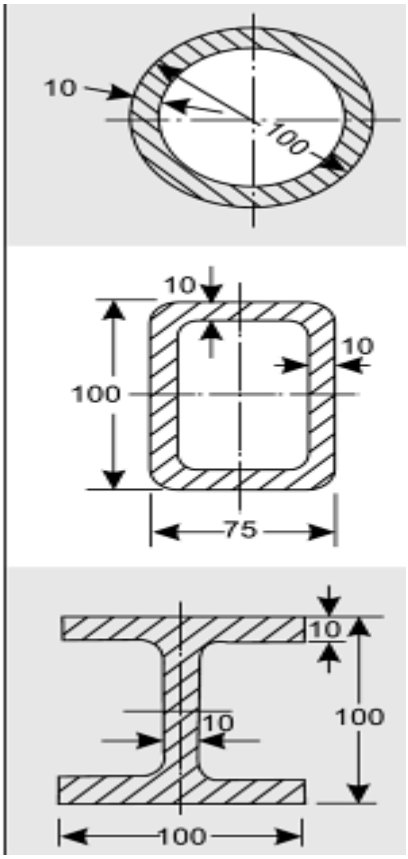
3 Cast iron has higher inherent damping properties, damping in steel structures occur mainly in welds; if welded joints are properly designed, the damping of steel structure may approach that of cast iron.

4 Cast iron has better sliding properties.

Any four related points 02 Marks

ii) Different profiles used in machine tool structure:-



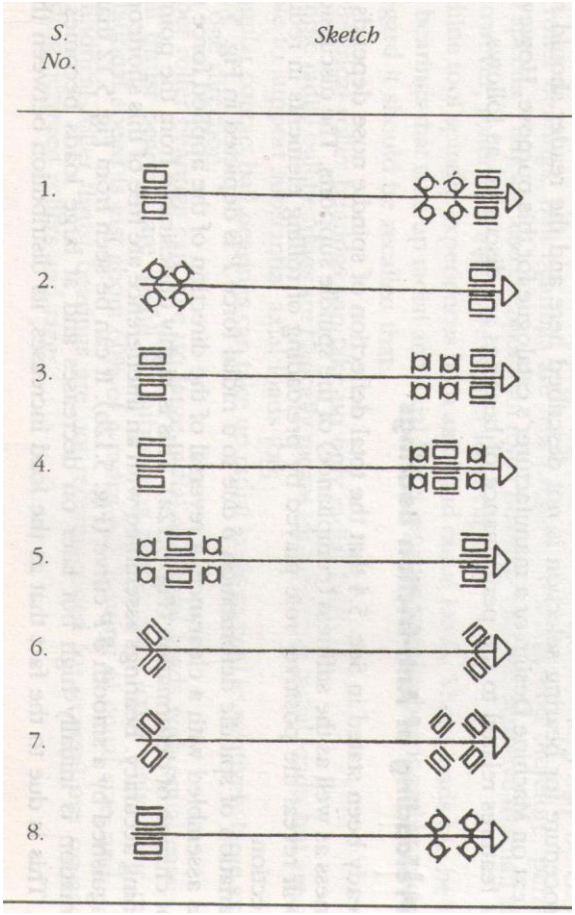


04 sketches 02 marks

Examples:- Bench and radial drilling machines, planning machines, vertical Lathe, Boring Machine, Grinding machine etc

Any four related examples 02 Marks

b) Different type of spindle supports:-



Eight figures 04 marks

The figure shows the typical combinations of majority of spindle units in small and medium size machine tools. Some important operational features of different types of bearings can be as under.

1 use the tapper roller bearings considerably increases both radial as well as axial run outs.

2 use of only cylindrical bearings at the front support greatly enhances axial thermal deformation of the spindle nose.

3 Use of angular contact bearings at the front support results in low heat generation

4 Use of zero film bearings can be used for sliding contacts.

Four points 04 Marks

C) Different sources of vibrations in Machine tools: and Methods to reduce it.

Sources of forced vibrations are of **two types** due to cutting process and due to Machine operations:-

1) Variable undeformed chip thickness due to inherent characteristics of certain machining operations, such as milling and broaching.
2) Variable undeformed chip thickness at the time when cutting tool enters the workpiece or comes out of it.
3) Change in cutting speed during operations such as facing.
4) Change in kinematic cutting angles in the direction of feed.
5) Due to errors in gears, splines and keys.
6) Due to disbalanced rotating parts.
7) Pulsating forces from coolant and hydraulic pumps.
8) Shocks transmitted through foundation.

Any eight points 04 Marks

Methods to reduce vibrations

1. **Change of cutting parameters:** Decrease the feed rate, depth of cut and cutting speed.
2. **Change of tool geometry:** Increase of rake angle and method of clamping of workpiece
3. **Change of characteristics of vibratory system:** The following methods can be employed:
   (i) Use tuned undamped vibration absorbers to counteract forced vibration with constant frequency.
   Example: Electromagnetic imbalance of motion.

(ii) Use of stiffner between table and over-arm of a horizontal milling machine, reduction of overhang of the tool in lathe, use of tighter clamping of workpiece, use of steady for long slender workpieces, etc.

(iii) Introduction of vibration absorbers in the vibratory system especially in boring, milling and turning operations.

l. **Modification of regenerative effect**

(i) The regenerative instability can be destroyed by the use of milling cutters of irregular tooth pitch for slab milling or different helix angles on successive teeth.

(ii) The regenerative instability can be destroyed by the use of continuously variable spindle speed under programme control.

Any 04 points 04 Marks

Q 4 A) Attempt Any Three

a) Factors to be consider while selecting material for Machine tool Structure:-

The final selection of cast iron or steel as the structure material will in most cases rest upon which of them provides for a lower cost of the structure. Correct selection can be made only on the basis of a comprehensive analysis of various factors, some of which are listed below.

(i) *Economy of metal*: Here it is important to remember that although the weight of the finished steel structure may be low, the actual metal consumption may be high. This is due to the fact that whereas holes in castings are obtained with the help of cores, those in welded structures have to be machined. This results not only in scrap but also in additional labour cost.

(ii) Cost of pattern and welding fixtures.

(iii) Cost of machining.

Explanation 01 Three points 03 Marks

b) Stepless speed drive

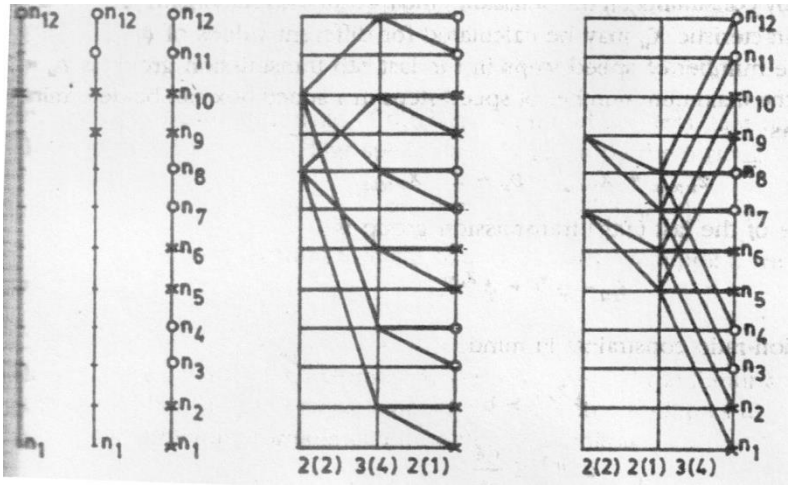
THE SYSTEM of stepless regulation is more common now-a-days in modern machine tools. By such system we can have practically no loss in speed and can arrange speed adjustment without stopping the machine. It reduces time losses and is therefore very useful in automatic machine tools. Stepless regulation can be effected by any one of the following methods :

- **Stepless Regulation**
  - Electrical system. (Ward-Leonard system gives a large speed range & thereby a near approach to stepless regulation)
  - Electronic system
  - Hydraulic system
  - Mechanical friction drive & pressure variators.

Examples:- Grinders, CNC Milling Machine, shaping machine, Planning Machine, Boring Machine etc.

Explanation 03 Marks and Examples 01 Marks

C) Layout of speed step



Advantages of GP series

it has been found that GP series are most suitable for providing variations to spindle speeds. Constant ratio of GP series for machine tool spindle speed is given by

$$\phi = \sqrt[E]{10}$$

where E is an integer.

The value of ϕ is usually selected according to preferred number. The value of preferred number depends upon the design requirements of machine tools and number of speeds required. It has the following advantages:

(i) unnecessary variations are eliminated
(ii) standarised motors and shafts can be used.

Layout -3 Advantages -1

d) Aesthetic consideration in Machine Tool:-

Aesthetic considerations are nothing but the overall appearance look of the machine from outside**.**

Good appearance of the machine tool influences the mood of the worker favourably and thus facilitates better operation. It is generally conceeded that a machine tool that is simple in design and safe in operation is also good in appearance, although factors, such as external finish, colour, etc. do substantially contribute to the overall aesthetic quality of the machine tool. For instance, painting of machine tools in grey-green or green-blue colours imparts a bright and pleasing appearance to the shop. Nowadays, painting of machines in different colours according to the production purpose is becoming popular, e.g., transportation facilities within the shop are painted yellow with black stripes, etc.

Meaning 01 Mark and Explanation 03 Marks

Q4 B) Attempt Any One

a)

i) Define Spindle Unit:- It is defined as the component of machine tool which rotates and clamp the workpiece or tool; depending on the requirement**.** E.g. Lathe, Drilling, Boring etc.

Definition 02 Mark

ii) Spindle unit of a machine tool performs the following important functions:-

1 Centering the workpiece e.g. In lathe ,Turret, Boring etc.

2 Clamping the workpiece or tool during the machining operation

3 Imparting rotary motion (in Lathe) or rotary cum translator motion (In drilling).

Any Two points 02 Mark

iii) Two requirements of spindle unit:-

1 The spindle should rotate with high degree of accuracy. Accuracy of rotation must not exceed the permissible limits which are specified depending upon the required machine accuracy.
2 The spindle unit must have the high static stiffness. The stiffness of the unit is made up of the unit proper and the bearings. Machine accuracy is influenced by bending, axial as well as torsional stiffness.
3 The spindle unit must have high dynamic stiffness and damping.
4 The deformation of the spindle due to heat transmission should not be large.

Any Two points 02 Mark

b) Feasibility of ray diagram is essential

An optimum ray diagram is one which will result in a compact gear box with less number of gears, shafts, bearings and shifting levers with a consequent minimisation of manufacturing cost. Size is minimised by minimising the shaft sizes subject to the constraints of ray and stage restriction. For minimising shaft sizes, summation of diameters of different gear box shafts have to be calculated from torque for alternative ray diagrams and the best layout is chosen. For a quick evaluation, node method is used ·

03 Marks for Explanation

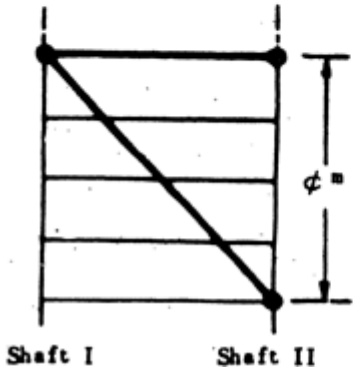
To check feasibility of Ray diagram:-

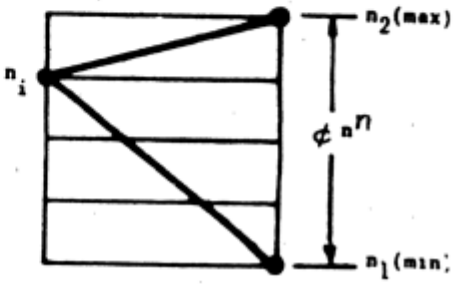
(i) *Ray restriction.* We know that in order to avoid interference, the minimum number of teeth in a set of gears should be greater than if (conveniently chosen as 20) and to avoid very large size gears, it should not be more than 120.

Therefore $|\phi^m|_{max} = \frac{120}{20} = 6$ where m = no. of intervening spaces.

(ii) *Stage restriction.* We further know that due to limitations of space and pitch line velocity, the transformation ratio in a gear box is constrained in the limits

$$\frac{1}{4} \leqslant \text{transformation ratio} \leqslant \frac{2}{1}$$





Looking into the following ray diagram.

$$\therefore \quad \frac{n_2}{n_1} < 2; \text{ and } \frac{n_1}{n_1} \leq 4 \quad \frac{n_2}{n_1} < 2 \times 4 < 8$$

In a stage $\phi^n \leq 8$ where n is the number of intervening spaces between n_1 and n_2.

Node Method of Optimisation

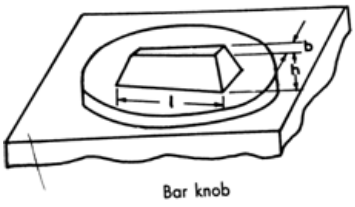
Node is a point from which a ray initiates or at which a ray terminates. Nodes are numbered from maximum speed and (corresponding to minimum torque) at each shaft and comparison is carried out with nodal sum (which, in fact, represents the sum of shaft diameters) as the criterion.

03 Marks for Explanation

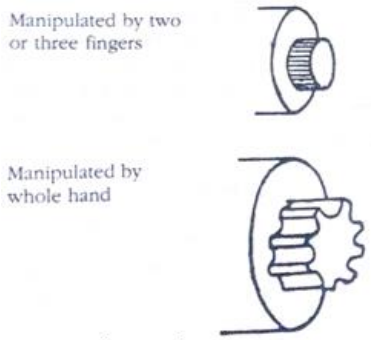
Q.5 Attempt any four

i)) Functions of knobs:

1) for making fine adjustments
2) as a selector (switching knobs)



Bar knob



Continuous function knobs

(02 marks for functions, 02 marks for sketch (any two types)

ii) Explain the concept of natural frequency of vibration.

Natural frequency is the frequency at which a system tends to oscillate in the absence of any driving or damping force. Free vibrations of any elastic body is called *natural vibration* and happens at a frequency called natural frequency. Natural vibrations are different from forced vibration which happens at frequency of applied force (forced frequency). If forced frequency is equal to the natural frequency, the amplitude of vibration increases many fold. This phenomenon is known as resonance.

Free vibration occurs when a mechanical system is set off with an initial input and then allowed to vibrate freely. Examples of this type of vibration are pulling a child back on a swing and then letting go or hitting a tuning fork and letting it ring. The mechanical system then vibrates at one or more of its "natural frequency" and damps down to zero.

In short natural frequency is the frequency of free vibration without damping. It is denoted by

'ω_n'.

Explanation for 04 marks

iii) Define speed chart. Why is it necessary?

Speed chart can be defined as an improved structural diagram which shows no speed stage, increase in speed and reduction in speed.

Necessity:

A structural diagram only depicts the range ratio of transmission groups but gives no information about transmission ratios, in order to determine the transmission ratios of all transmissions and the r.p.m values of speed box shafts, it is necessary to plot the speed chart.

(02 for definition and 02 for explanation)

iv) Define common ratio. State factors on which selection of common ratio depends.

Common ratio:-

$$\phi = \sqrt[n-1]{\frac{N_n}{N_1}}$$

Factors on which selection of common ratio depends:-

Depending on the common ratio, basic series are formed; these are R_5, R_{10}, R_{20}, R_{40}, and R_{80}.These are named as Renard series. Many other derived series are formed by multiplying or dividing the basic series by 10, 100 etc.

Typical values of the common ratio for four basic G.P. series are given below.

R5 :	$\sqrt[5]{10}$	*1.58 :* 1.0, **1.6**, 2.5, 4.0,...
R10 :	$\sqrt[10]{10}$	*1.26 :* 1.0, **1.25**, 1.6, 2.0,...
R20 :	$\sqrt[20]{10}$	*1.12 :* 1.0, **1.12**, 1.25, 1.4,...
R40 :	$\sqrt[40]{10}$	*1.06 :* 1.0, **1.06**, 1.12, 1.18,...

(02 marks for definition, 02 marks for any two factors)

v) Antifriction guide ways:

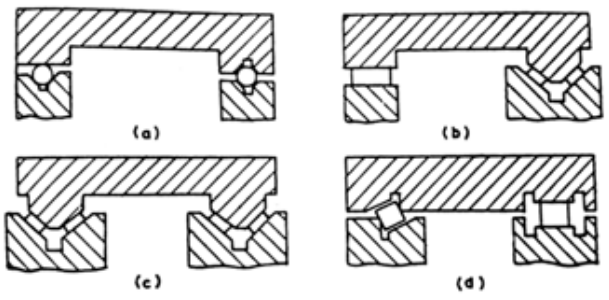


Fig. Open-type anti-friction ways

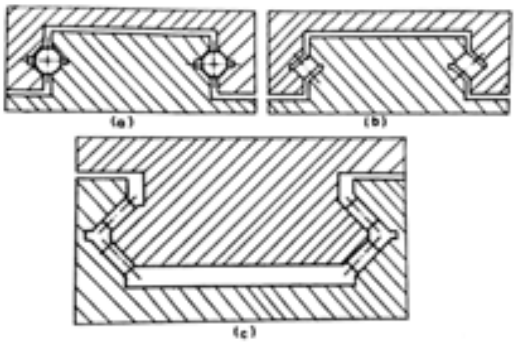


Fig. Closed-type anti-friction ways

(2 marks for open ad 2 marks for closed)

vi) **What is osmostatic slide ways? State its advantages over conventional guide ways.**

In osmostatic slide ways gas-friction conditions at the interface of mating surfaces are achieved by supplying compressed air under pressure. It is similar to that of hydrostatic slide ways, the basic difference being that the lubricating medium in this case is compressed air instead of oil.

Advantages –

1. It is not necessary to collect oil as in case of hydrostatic slide ways,
2. The moving member can be reliably clamped in the desired position after cutting off the supply of compressed air,
3. Due to air pressure the mating surfaces are effectively protected from dust, abrasive particles and chips, and
4. The pulling force requires to displace even heavy units is very small due to negligibly small friction at all sliding velocities.

Explanation 02 Marks Advantages 02 Marks

Q6 : Attempt Any Four:

i)

Given Data

$N_1 = N_{min} = 12$ rpm

$N_n = N_{max} = 510$ rpm

$z = 8$

$\phi = \sqrt[z-1]{\frac{N_n}{N_1}}$ ---------- 1M

$= \sqrt[7]{\frac{510}{12}}$

$\phi = 1.708$ ---------- 1M

Speed steps

$n_1 = n = 12$

$n_2 = n_1 \times \phi$

$= 12 \times 1.708 = 20.49$

$n_3 = n_2 \times \phi = 20.49 \times 1.708$

$= 34.99$

$n_4 = 59.76$

$n_5 = 102.07$

$n_6 = 174.33$

$n_7 = 297.76$ ---------- 2M

ii) Note: figures are not essential but preferred)

Ergonomic considerations in design and location of display and control members:-

i) the accuracy of the dial or scale should be in accordance with the accuracy required.
ii) The dial or scale should not give any superfluous information.
iii) The necessary information should be provided to the operator in the simplest possible manner.(to avoid the conversions and computations)
iv) The subdivisions should be for values 1,2 or 5; subdivisions of 2, 4 etc should be avoided.
v) The scale or dial should not be overcrowded and figures should be written only on the large markings.
vi) The pointer tip should not cover the figure or scale markings.

Ergonomic considerations

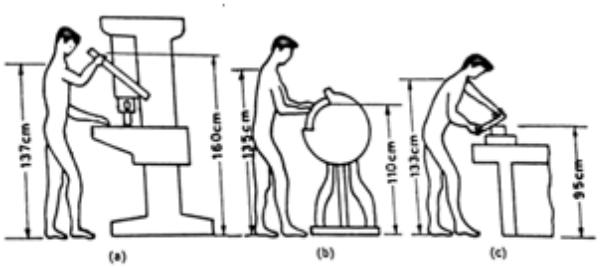
i) The optimum angles of the location, which cause least fatigue on the neck and other relevant muscles for standing and sitting operator.

ii) The scale and indicators of displays should be positioned such that parallax is minimum.

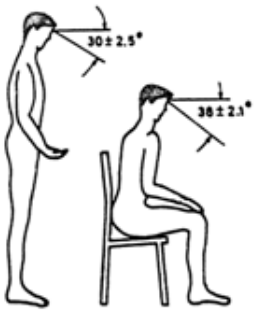
iii) The location of control members such as lever, hand wheels etc is governed by the anthropometric and functional anatomy considerations.

Example of scale subdivisions corresponding to 1

Example showing markings that should be numbered



Location of various control members while: (a) operating a lever, (b) grinding a tool, (c) working on a bench



Recommended range of location of displays

(02 marks for design considerations, 02 marks for ergonomics (any two points)]

iii) (01 mark each, any four)

1) Anti-friction bearings (roller bearing, ball bearings)

2) Hydrodynamic bearings

3) Hydrostatic bearings

4) Air – lubricated bearings

iv) Suitable guideways:

a) Planning machine – open V type slide ways

b) surface grinders- Flat type

c) Lathe tailstocks – cylindrical slide ways

d) Small vertical drills - Half closed type

v) Machine tool structure profile mostly used in machine tools:

Box type structures are mostly used as a machine tool structure

Reason:-

1. Box type section has the highest torsional stiffness.
2. The strength is high as compared to other structures.
3. Proper mating with the other surfaces.

(01 mark for type, 03 marks for reasons (any three))
