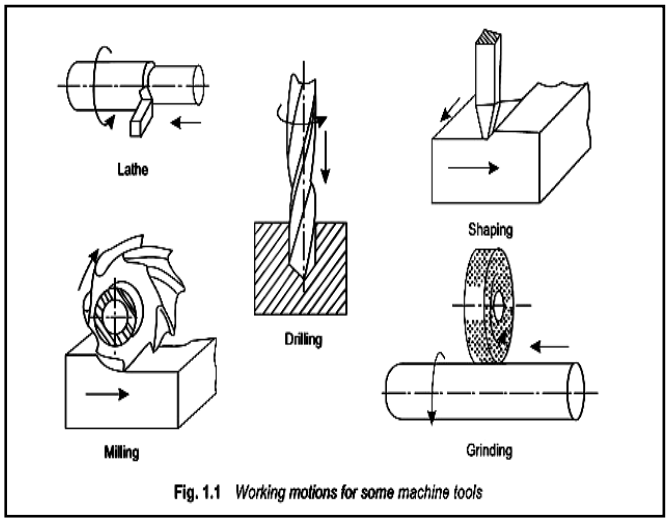
WINTER– 16 EXAMINATION
Model Answer

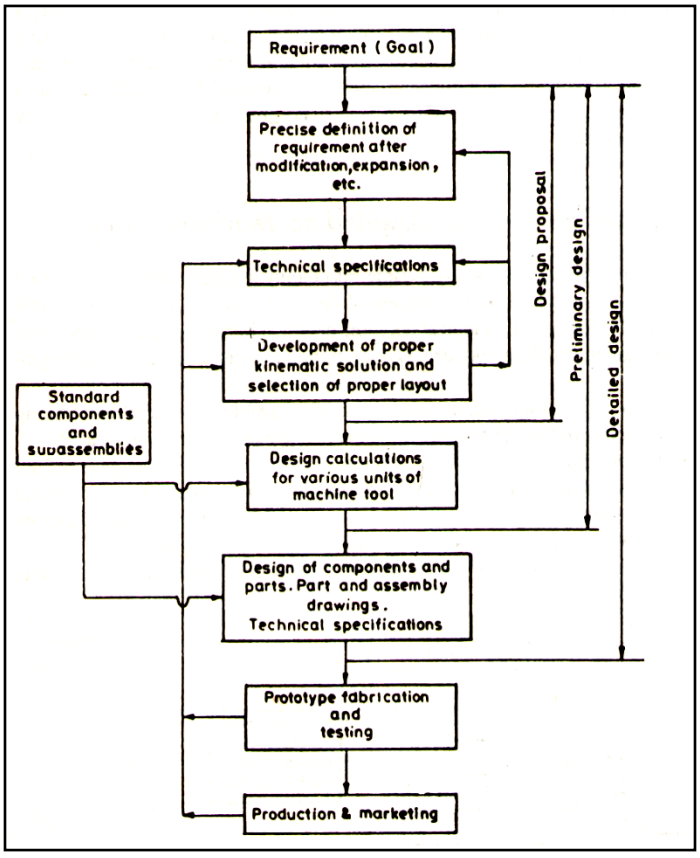
Subject Code: 17532

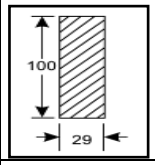
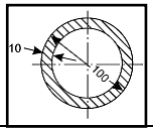
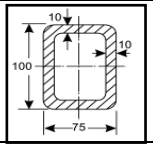
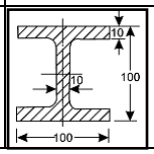
Important Instructions to examiners:

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 judgment 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. No.	Sub Q. N.	Answer	Marking Scheme
1	a) (i)	**Attempt any THREE of the following:** **How machine tools are classified** 1) According to direction of major axis ▪ Horizontal center lathe, horizontal boring machine ▪ Vertical lathe, vertical axis milling machine ▪ Inclined- special (e.g. Transfer machine) 2) According to purpose of use: ▪ General purpose – e.g. center lathes, milling machines drilling machines etc ▪ Single purpose- e.g. facing lathe, roll turning lathe etc ▪ Special purpose- for mass production 3) According to degree of automation ▪ Non-automatic- e.g. center lathes, drilling machines etc. ▪ Semi-automatic – capstan lathe, turret lathe, hobbing machines etc. ▪ Automatic- e.g. single spindle automatic lathe, Swiss type automatic lathe, CNC milling machine etc. 4) According to size ▪ Heavy duty- e.g. heavy duty lathes (e.g. > 55 kW), boring mills, planning machine, horizontal boring machine etc. ▪ Medium duty- e.g. lathes 3.7 ~ 11 kW, column drilling machines, milling machines etc. ▪ Small duty- e.g. table top lathes, drilling machines, milling machines. ▪ Micro duty- e.g. micro-drilling machines etc.	4 Marks
	(ii)	**State requirements of machine tool structures (any four)** Machine tool structure 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 ensures that working stresses and deformations do not exceed specific limits. It should be noted thet the stresses and deformations are due to mechanical as well as thermal loading. The design feature that provide for ease of manufacture, maintenance, etc., are peculiar to each structure and will, therefore be discussed seperately for different structures. However, there are two common features which are fundamental to the satisfactory fulfilment of above requirements for all structures, These are: 1. Proper selection of material 2. High static and dynamic stiffness.	4 Marks
	(iii)	**Describe stick-slip phenomenon in case of guide ways.** In a machine tool either the table is holding the work piece or the saddle holding the cutting tool moves very slowly over suitable guides and at the same time is subjected to heavy forces caused by cutting and clamping. In such sliding cases often a time dependent intermittent motion is noted which causes consecutive sticking and slipping of the slide at regular intervals. This regularly repeated motion is known as stick-slip motion. This stick-slip motion when exist is found to worsen surface finish and dimensional accuracy of the product and also reduces the overall life of the machine tool and the cutting tools. Therefore for satisfactory machining performance it is essential to eliminate or reduce the stick-slip motion. This requires of being acquainted with the stick-slip characteristics and the role of various parameters on it. The principle agents which are responsible for stick-slip motion under low speed and large forces are the elasticity of the sliding elements and the frictional characteristics at the sliding surfaces.	4 Marks
	(iv)	**What are the working motion and auxiliary motions in machine tools? Describe with suitable example.** For obtaining the required shape on the workpiece, it is necessary that the cutting edge of the cutting tool should move in a particular manner with respect to the workpiece. The relative movement between the workpiece and cutting edge can be obtained either by the motion of the workpiece, the cutting tool, or by a combination of the motions of the workpiece and cutting tool. These motions which are essential to impart the required shape to the workpiece are known as working motions. **Working motions** can further be classified as: 1. Drive motion or primary cutting motion 2. Feed motion Working motions in machine tools are generally of two types: rotary & translatory. Auxiliary motions that are required to prepare for machining and ensure the successive machining of several surfaces of one workpiece or a similar surface of different workpieces.  Fig. 1.1 *Working motions for some machine tools*	2 Marks

		The auxiliary motions do not participate in the process of formation of the required surface but are nonetheless necessary to make the working motions fulfill their assigned function. Examples of auxiliary motions in machine tools are clamping and unclamping of the workpiece, idle travel of the cutting tool to the position from where cutting is to proceed, changing the speed of drive and feed motions, engaging and disengaging of working motions etc. In machine tools, the working motions are powered by external sources of energy (electrical or hydraulic motor). The auxiliary motions may be carried out manually or may also be power-operated depending upon the degree of automation of the machine tool. In general-purpose machine tools, most of the auxiliary motions are executed manually. On the other hand in automatic machines all auxiliary are automated and performed by the machine tool itself. In between these two extreme, there are machine tools in which the auxiliary motions are automated to various degrees. i.e., some auxiliary motions are automated while others are performed manually.	2 Marks
	b)	**Attempt any ONE of the following:**	
	(i)	**Explain general design procedure of machine tools with suitable block diagram.** 1. Requirement-The customer outlines the requirements by furnishing information about the parts for machining of which he wants the machine tool to be designed. 2. Technical specification- the technical specification is the listing of parameters that are essential for the design. 3. Selection of proper kinematic solution and layout- after technical specification has been laid down the designer explores the combination of relative motions that can ensure machining of surfaces of required shapes and dimensions. 4. Design calculations- the design calculations cover the design of the major units of the machine tools such as speed box, feed box, belt. Spindle etc. 5. Drawings of components and assemblies- These drawings are made for the version that is finally selected. The drawings must be complete with dimensions, tolerances and manufacturing specifications. (Including the manufacturing method to be employed.)  	Figure - 3 Marks Explanation – 3 marks

	(ii)	**What are different shapes of structures used in machine tools? Draw neat sketches and state which one is best.** **Different shapes of structures used in machine tools:-** Rectangular  Cylindrical  Box type  I-section  **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.	3 Marks 3 Marks
2.	**a)**	**Attempt any FOUR of the following:** Define: **a) 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. **b) Service Factor** Machine tools working at different parameters like speeds, feeds than theoretical which were used while designing so it is necessary to consider actual working conditions to determine the forces, vibration frequencies etc. for smooth working of machine tool. Service factor takes care of all such variations. It is difficult of any machine tool to determine the parameters exactly like magnitude and direction of forces, vibrations etc., therefore we cannot predict the failure of any component of the machine tool exactly or we can't determine the exact failure stress values. Also the working environment in which machine tool works is also dynamic (continuous changing) therefore we can't predict the performance of machine tool. For all such problems it is must to consider the service factor.	2Marks 2 Marks

b) State the functions and requirements of guideways (four each).

Functions of guideways — 2 Marks

i. To have low friction as compared to slideways
ii. Should have uniformity of motion even at slow speeds.
iii. Should have high stiffness if the rolling members are preloaded.
iv. Possibility of using high velocity of motion.

Requirements of guideways — 2 Marks

i. It should be strong
ii. It should process sufficient stiffness
iii. There should be less wear
iv. The pressure distribution should be uniform.
v. It should provide good guidance
vi. There should be less friction.

c) Calculate the rpm values and diameter range served by each rpm for the following conditions n_1=30 rpm, n_2 = 375 rpm no. of speed steps z = 4, v = 20m/min for geometric progression

Give Data:

Minimum Speed = n_1 = 30 rpm Maximum Speed = n_z = 375 rpm
Number of speed steps = z = 4 Cutting Velocity = v = 20m/min

$\emptyset$ = Common ratio = $\sqrt[z-1]{\frac{n_z}{n_1}}$

$= \sqrt[4-1]{\frac{375}{30}} = \sqrt[3]{12.5} = 2.32$

Therefore spindle speeds are as follows;

n_1 = 30 rpm , n_2=70 rpm, n_3 = 162 rpm, n_4 = 375 rpm — 2 Marks

and diameter range for above speed can be calculated by formula

$$D = \frac{1000 \times V}{\pi \times N}$$

By putting each values of spindle speed the diameter range obtained is as follows;

d1 = 318.30 say 320mm d2 = 136.42 say 140mm d3 = 58.95 say 60mm d4 = 25.46 say 25mm — 2 Marks

d) Write advantages of G.P. series used in spindle speeds.

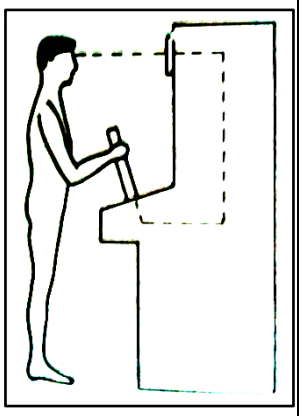
a) Constant loss of economic cutting speed in whole rpm range.

b) Constant loss of productivity in whole rpm range.

c) Better Design features

d) Range of operational speeds are decided on the basis of preferred numbers of G. P. series — 4 Marks

e) Explain with suitable example man-machine relationship in machine tools



The interaction between an operator and the machine which he operates best understood by considering the two as elements of a closed-loop system as shown in figure. In this man machine system, the operator serves the following two main functions:

1. Sensing and information processing
2. Energy source for imparting a controlling or correcting motions to the appropriate control member of the machine

The man machine interaction needs elaboration to enable a proper appreciation of the design requirements of the control members. Operator receives information about the operation by direct visual observation or from instruments and displays. In either case operator processes the information in his brain. On the basis of this processed information the operator decides upon a certain course of action and imparts the necessary motion to an appropriate control member.

The ability of an operator to successfully carry out the functions described above is restricted by his:

1. Physical size
2. Capacity to apply force, and
3. Ability to observe the process carefully and manipulate the appropriate control members with necessary precision.

The overall efficiency of the man-machine system includes both man and machine. A machine with the best of design may fail to deliver the goods if its operation is not suited to the physical, physiological and mental capabilities of the operator. The science which deals with man-machine interaction is known as ergonomics.

4 Marks

3. Attempt any two of the following:

a) Explain with neat sketch effect of stiffener arrangement on the bending and torsional stiffness of box type structures.

Table 3.5 Effect of stiffener arrangement on the bending and torsional stiffness of box-type structures

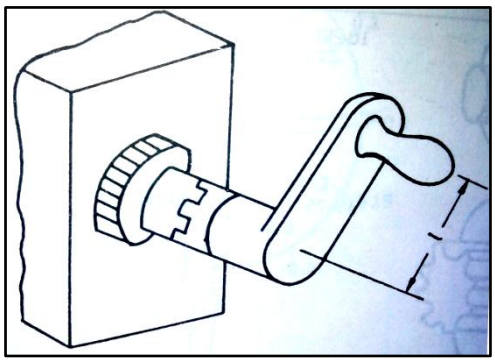
Stiffener arrangement	Relative stiffness under		Relative weight	Relative stiffness per unit weight under	
	Bending	Torsion		Bending	Torsion
1	1.0	1.0	1.0	1.0	1.0
2	1.10	1.63	1.1	1.0	1.48
3	1.08	2.04	1.14	0.95	1.79
4	1.17	2.16	1.38	0.85	1.56
5	1.78	3.69	1.49	1.20	3.07
6	1.55	2.94	1.26	1.23	2.39

Table – 5 Marks

From above table it is seen that only stiffeners used shown in arrangements 5 and 6 provide significant improvement in bending and torsional stiffness of box-type structures. 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 arrangements of stiffeners

3 Marks

	b)	**Sate the function, requirements and materials of spindle unit.** **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). **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. **Material of spindle unit** i. For normal accuracy spindles C 1045 steels, hardened and tempered to HRC 30 ii. For above normal accuracy spindles steel 5140 (AiSi). HRC 50 – 55, induction hardened. iii. For spindles of precision machine tools. Low alloyed steel 5120 (AiSi) HRC 55 – 60 case hardened.	3 Marks 3 Marks 2 Marks
	c)	**What are the types and sources of vibration in machine tool? Give any two methods of reducing it.** **Types of vibration in machine tool** 1) Forced Vibration 2) Self excited vibrations **Sources of vibration in machine tool** 1) Unbalanced of rotating parts 2) Misalignment of coupling and bearing 3) Defective drive 4) Interference in gears 5) Self induced vibrations because of cutting process (tool chatter) are generated and changes its magnitude. 6) Hydraulic forces 7) Aero dynamic forces 8) Mechanical looseness or insufficient rightness of fasteners. **Following are methods to reduce the vibration in machine tool** 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 work piece 3. Change of characteristics of vibratory system: The following methods can be employed: (i) Use tuned undamped vibration absorber to counteract forced vibration with constant frequency. Example: Electromagnetic imbalance of motion (ii) Use of stiffener between table and over-arm of a horizontal milling machine, reduction	2 Marks 3 Marks

		of overheating of the tool in lathe, use of tighter clamping of workpiece, use of steady for long slender workpieces, etc. (iii) Introduction of vibration absorber in the vibratory system especially in boring, milling and turning operations. 4. 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.	3 Marks
4	**a)** **i)**	**Attempt any THREE of the following:** 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. **Material properties:-** 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.	4 Marks
	ii)	Speed chart can be defined as an improved structural diagram which shows no speed stage, increase in speed and reduction in speed. **Importance** 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.	4 Marks
	iii)	The following information is essentially required 1.The highest output rpm, n_{max} , 2.The lowest output rpm, n_{min} , 3.The number of steps z into which the range between n_{max} and n_{min} is divided, and 4.The number of stages in which the required number of speed steps are to be achieved	4 Marks
	iv)	**Design of Levers** A lever is a rod-like control working in one direction about a fulcrum. Levers are used as continuous function control members in feeding devices when: 1. The length of travel is small, 2. Fast movement of travel is required but accuracy of movement is not of much importance, and 3. Load is medium to heavy. In addition, levers are used as a step-function control member is speed and feed changing mechanisms.  Levers acting as continuous-function control members can be of the following two types: 1. Vertical Levers which are operated by pushing away from or pulling towards the body, and	2 Marks

2. Vertical levers which are operated by pushing across the body

Small-size step-function levers are generally used for switching purposes.

Medium-size discrete-positioning levers are used in speed and feed changing mechanisms of machine tools.

Design of Hand Wheels

A hand wheel is a circular control member which is gripped by the rim or a handle during operation. They are used in feed mechanism of machine tools for manual feeding of the tool during cutting and accelerated manual travel of the tool for setting.

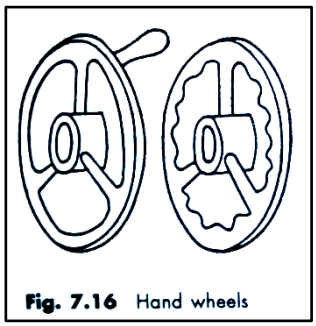


Fig. 7.16 Hand wheels

Operating the hand wheel by gripping the rim is proffered when:

1. Turning speed is low (1 rpm or less),
2. Accurate partial turns are required, and
3. Torque required is greater than 20 kgf cm.

2 Marks

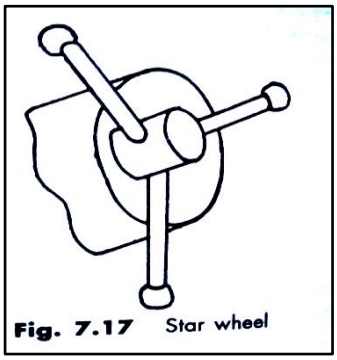


Fig. 7.17 Star wheel

The size of the hand wheel depends upon the torque resistance. The large size hand wheels of 400 mm diameter and above should have a wavy inside surface of the rim to ensure good grip without slipping (shown in figure 7.16).

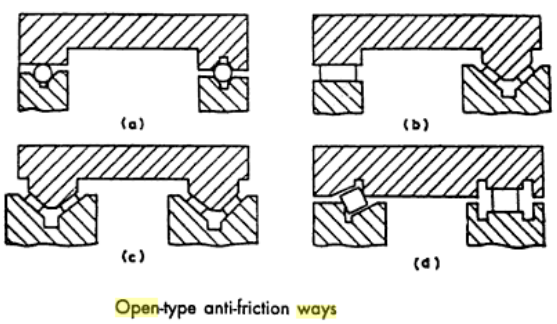
A star wheel consists (figure 7.17) of three or more levers attached to a shaft. When a star wheel is operated by one hand, its working is similar to that of rotary lever except that it provides the operator the choice of using a lever which is most convenient to him.

b) Attempt any ONE of the following:

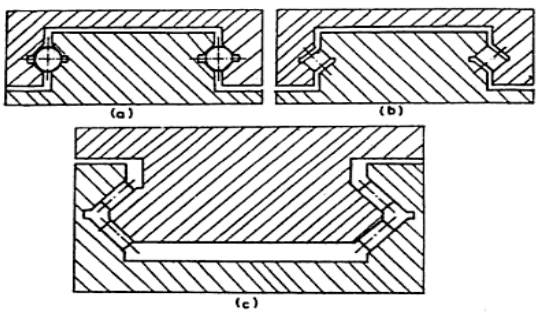
i) In anti-friction ways intermediate rolling members (balls & rollers) are inserted between the sliding surfaces, thus changing the nature of friction from sliding to rolling. The contact of rolling members with guideway surfaces occurs over a point or a line. The line or point contact follows the profile of the guideway surface and reproduce it on the machined surface.

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.

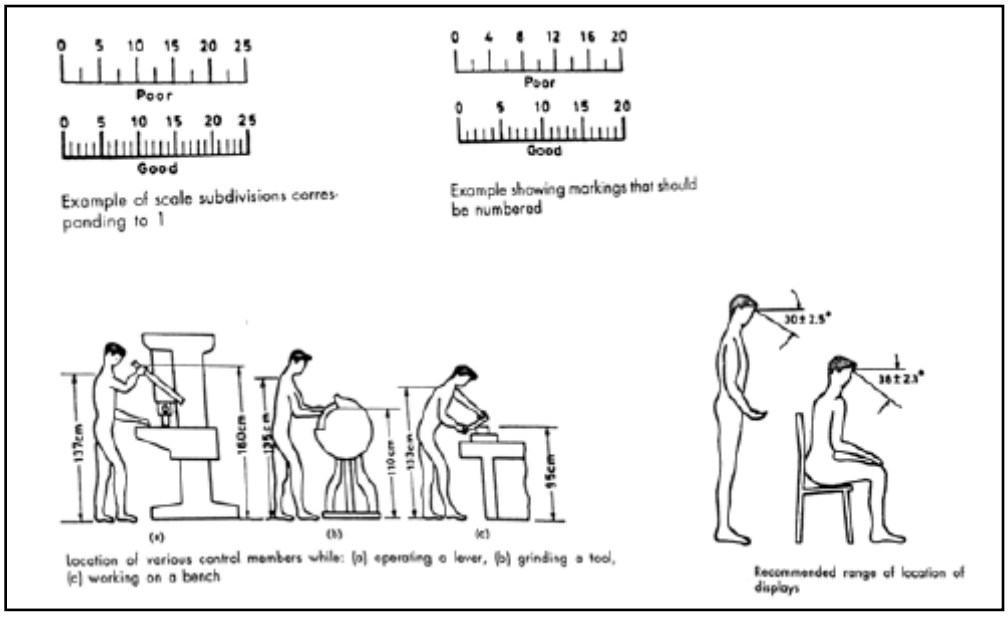
Closed-type anti-friction guideways are used when working loads are relatively large and guideways are required to have high stiffness. Higher stiffness is achieved through preloading of rolling members. As a matter of fact horizontal rolling members automatically experience some preloading due to the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

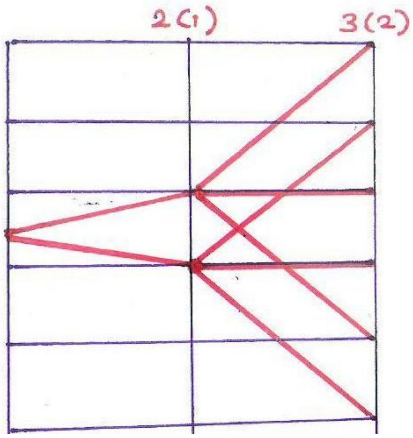
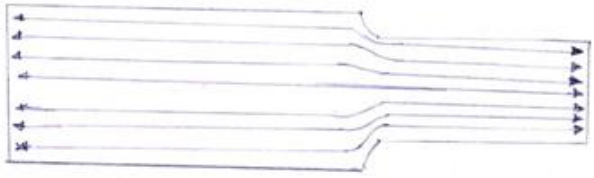
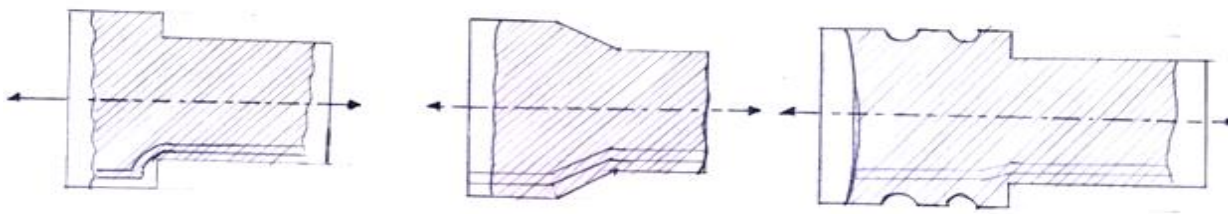


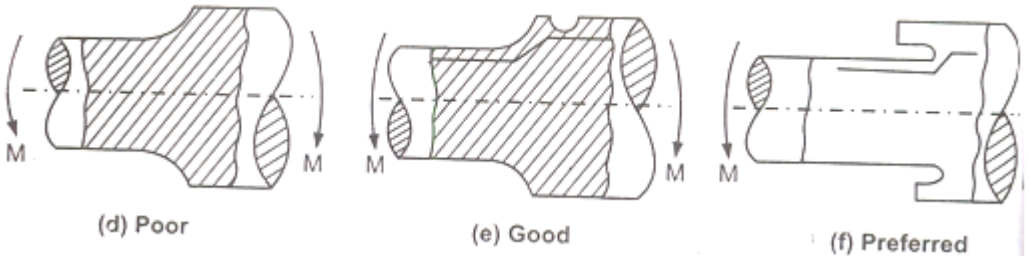
Open-type anti-friction ways



Closed-type anti-friction ways

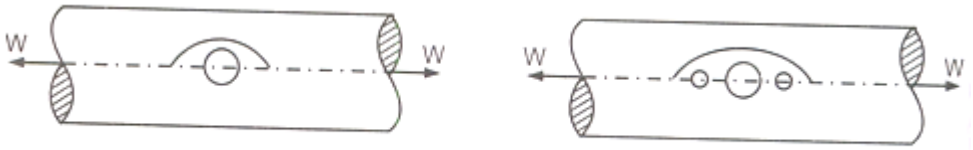
	ii)	Selecting the best structural diagram: 1. The number of gears on the last shift (spindle) should be the minimum possible, 2. The transmission ratio between the spindle and the shaft preceding it should be the maximum possible, i.e. speed reeducation should be the maximum possible, and 3. The number of gears on the shafts should not generally be more than three, though in exceptional cases it may be four.	
5		**Attempt any FOUR of the following:** **Note: figures are not essential but preferred)**	4 Marks
	i)	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. The location of control members such as lever, hand wheels etc is governed by the anthropometric and functional anatomy considerations.	
	ii)	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	4 Marks

		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.	
	iii)	**Feasibility of structural formula 2(1)3(2) for geometric ratio 1.58.** The structural diagrams are drawn from the structural formulae which is a graphical tool used to find the range ratio of transmission groups. The structural diagram gives information about the number of shafts and the number of gears on each shaft. The order of changing transmissions in individual groups to get the desired spindle speed and The transmission range and characteristics of each group. The ray diagrams are incorporated to make the design more feasible with respect to the transmission ratio and number of teeth used in gearbox. 	4 Marks
	iv)	Essential requirement for layout of stepped drive. The layout of a ray diagram depends on the fixation of; a) Greatest amount of r.p.m. b) Least output r.p.m. c) Number of steps of the transference d) The manner of subdivision of steps e) The number of stages in which the steps are to be obtained.	4 Marks
	v)	**Stress concentration.** The machine component changes the shape of its cross-section, the simple stress distribution no longer holds good. This irregularity in the distribution caused by abrupt changes of form is called stress concentration.  **Methods to reduce effect of stress concentration.** 1) The following fig shows that stress lines tend to bunch up and cut very close to the edges or sharp corner, in order to improve fillets may be provided  2) Reducing stress concentration in case of cylindrical members with shoulders.	4 Marks



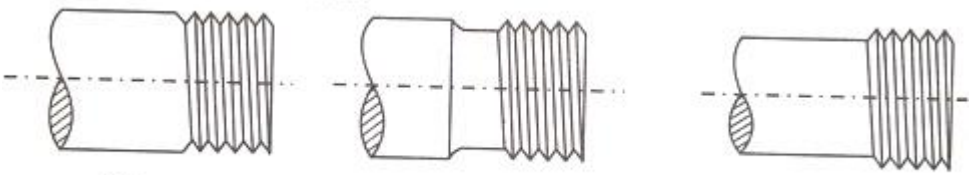
(d) Poor (e) Good (f) Preferred

3) Reducing stress concentration in case of cylindrical members with holes.



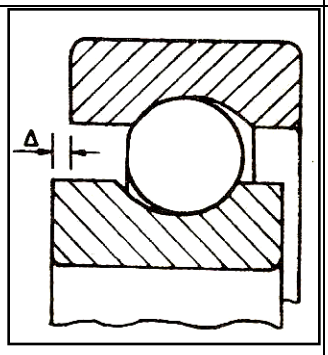
(g) Poor (h) Preferred

4) Reducing stress concentration in case of cylindrical members with threads.



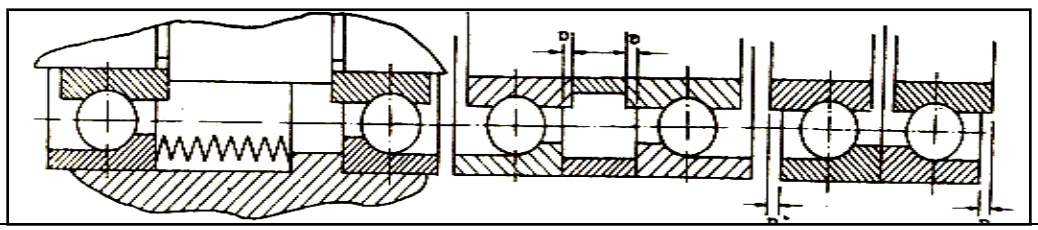
(i) Poor (j) Good (k) Preferred

vi) Preloading of a bearing involves relative axial displacement of the inner and outer races by a small amount. The methods of applying preloading in radial and angular contact ball bearings that are generally mounted in pairs are shown in fig. constant preloading is achieved either by grinding off the faces of the inner races or by inserting spacing rings of different widths between the inner and outer races If the bearing rotates at high rpm, the initial preload has a tendency to weaken. In such cases, especially when bearings are small, the preloading can be applied by means of springs which ensure a constant preload that can be accurately adjusted. This method is adopted in precision bearings.



4 Marks

Cylindrical double roller bearings are generally mounted on tapered journals. The preloading is obtained through axial displacement of the inner ring with an adjusting nut The utility of this arrangement can be considerably improved by using a split nut. As the bearing wears, the pre-set value of preloading decreases. When this occurs, the split nut is removed, slightly ground and mounted again. The initial preloading is then reinstated by additional axial displacement of the adjusting nut by a distance equal to the ground layer removed from the split nut. However, this procedure should be discontinued after a few regrinding of the split nut because when the bearing wear becomes large, the roller length is partially in contact with the worn surface of the race way and partially with the unworn surface. This results in excessive heat generation and no uniform rotation. Axial



		displacement of the bearing race by the threaded nut does not provide uniform contact of the face and can result in deformation of the spindle.	
6		**Attempt any two of the following:**	
	i)	Common ratio is nothing but a geometric progression ratio which can be used to determine the speed steps. $\phi = \sqrt[n-1]{\frac{N_n}{N_1}}$ Standard values for common ratio are 1.06,1.12,1.26,1.41,1.58,1.78 & 2. 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,...	4 Marks
	ii)	Bearings used as spindle support are as below- 1) Antifriction bearings 2) Sliding bearings a)Sleeve bearings b)Hydrodynamic journal bearings c)Hydrostatic journal bearings d)Anti-lubricated bearings The deflection of spindle nose depends, besides other factors, upon the compliance of the front and rear spindle supports. The rotational accuracy, which is one of the basic functional requirements of spindles, is also greatly influenced by the choice of bearing. A machine tool spindle experiences both axial and radial loads. These loads can be either balanced by bearings that take up load radial and axial load separately or by bearings that take up both. The common requirements of spindle supports can be specified as guiding accuracy, high stiffness, minimum heating, as it can lead to additional spindle deformation, vibration stability and ability to perform satisfactorily under varying conditions of spindle rotation.	4 Marks
	iii)	Aesthetic consideration in Machine Tool:- Aesthetic considerations are nothing but the overall appearance look of the machine from outside. Good appearance of machine tool influences the mood of the worker favorably and thus facilitates better operation. it is generally conceded that a machine tool that is simple in design and safe in operation is also good in appearances, all through factor, such as external finish ,color, etc. do substantially contribute to the overall aesthetic quality of machine tool. for instant, painting of machine tools in grey- green or green-blue colors imparts a bright an pleasing appearances to the shop .now a days, painting of machines in a different colors according to the production purpose is becoming popular, e.g. transportation facilities within the shop are painted yellow with black strips, etc.	4 Marks

	iv)	**Hydrostatic Slideways** In hydrostatic slideways liquid-friction conditions at the interface of mating surfaces are achieved by supplying a lubricant under pressure, which is large enough to raise the sliding body and precludes metal-to-metal contact. Hydrostatic slideways are distinguished by: 1. High load capacity at all sliding speeds, including zero speed. 2. No starting friction, extremely low running friction and consequently almost negligible wear, 3. High stiffness 4. Good damping, and 5. High uniformity and accuracy of feed and setting motions. One of the drawbacks of hydrostatic slideways is the difficulty in fixing the moving member in a desired position. However, the single major factor which goes against these slideways is their high cost on account of an elaborate lubricating system. This restricts their application to sophisticated and expensive machine tools, such as grinding machines, heavy-duty horizontal boring machines, programme-controlled and copying machines, etc. **Hydrodynamic slideways** In hydrodynamic slideways liquid friction conditions between sliding surfaces are achieved due to hydrodynamic action of the lubricant film. A sufficiently large hydrodynamic force which is capable of lifting the guided member is possible only at high sliding speeds. Hydrodynamic slide ways are, therefore, used mainly where the sliding motion represents the primary cutting motion, e.g., vertical boring and turning mills and planning machines. Hydrodynamic action is possible between sliding bodies only if they are inclined to each other, i.e., they form a wedge.	2 Marks 2 Marks
	v)	**Recent trends in manufacturing of machine tool structures.** 1) four axis CNC with twin turret 2) special purpose machine 3) Numeric control machine 4) flexible manufacturing system 5)CNC	4 Marks