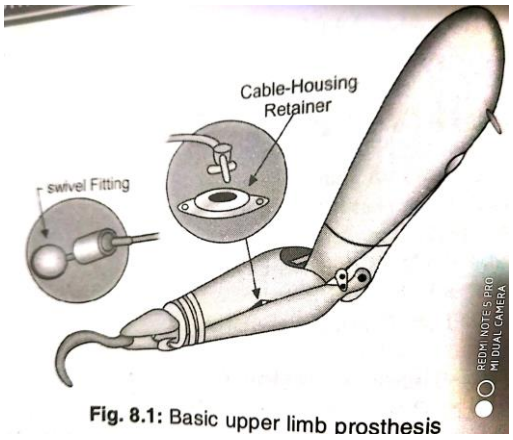
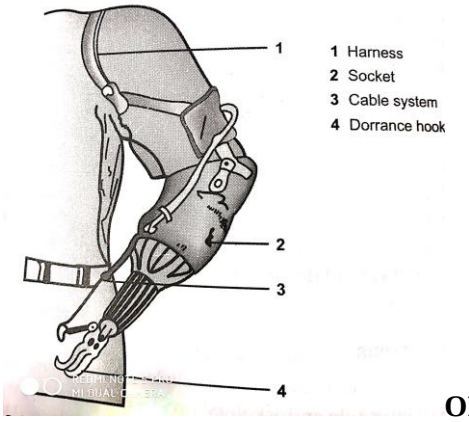
WINTER – 2022 EXAMINATION
Model Answer

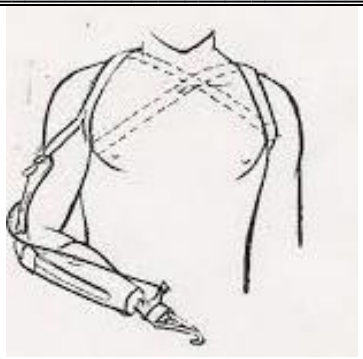
Subject Name: **Rehabilitation Engineering** **Subject Code:** **22545**

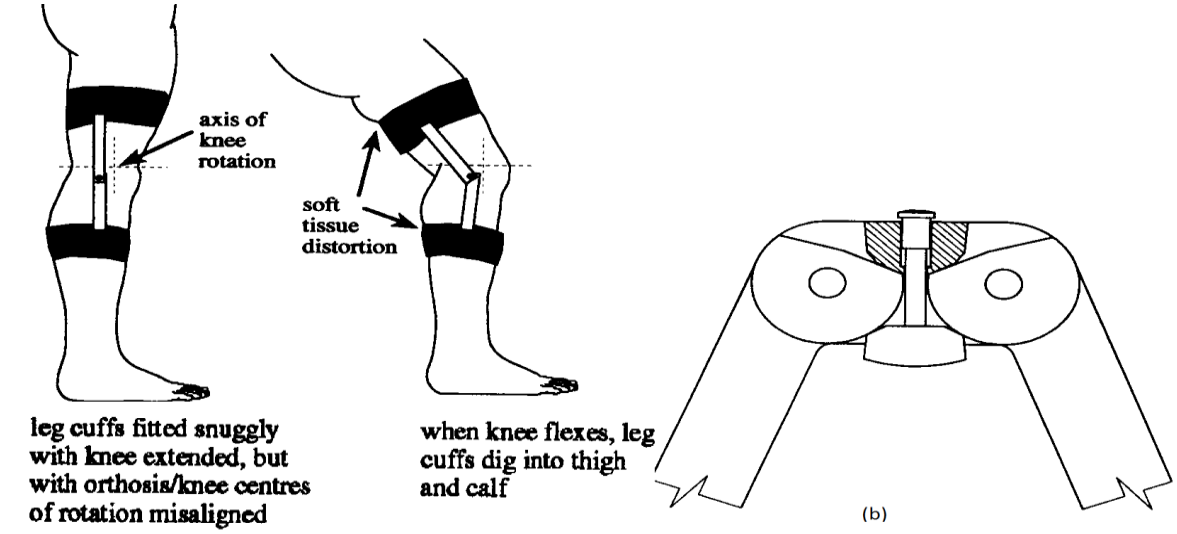
Important Instructions to examiners:

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.
8) As per the policy decision of Maharashtra State Government, teaching in English/Marathi and Bilingual (English + Marathi) medium is introduced at first year of AICTE diploma Programme from academic year 2021-2022. Hence if the students in first year (first and second semesters) write answers in Marathi or bilingual language (English +Marathi), the Examiner shall consider the same and assess the answer based on matching of concepts with model answer.

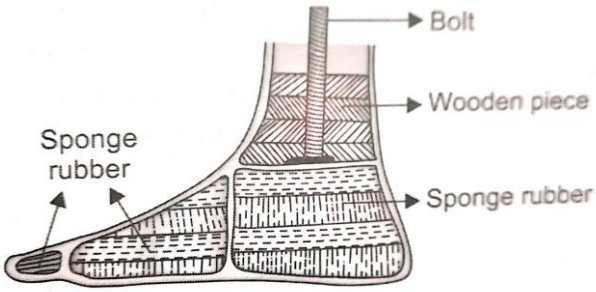
Q. No.	Sub Q. N.	Answer	Marking Scheme
1		**Attempt any FIVE of the following:**	**10** Marks
	a)	**Define rehabilitation engineering.** **Ans:** Rehabilitation focuses on the existing capacities of the handicapped person, and brings him to the optimum level of his or her functional ability by the combined and coordinated use of medical, social, educational and vocational measures. It makes life for the handicapped individual more meaningful, more productive and therefore adds more life to years.	**02** M
	b)	**Enlist various Rehabilitation team members.** **Ans:** **The medical team members are:** • Physiatrist • Plastic surgeon • Orthopedic surgeon • Neurologist • Neurosurgeon • Psychiatrist • Pediatrician • Obstetrician **Paramedical team members are:** • Physiotherapist • Occupational therapist • Creative movement therapist • Recreation therapist • Prosthetist-orthotist • Rehabilitation nurse **Sociovocational team members are:** • Social worker • Vocational counselor • Vocational evaluator • Skilled instructors • Placement officers • Child development specialist • Special educator	**02** M **(Any four)**

• Geneticist • Neonatologist • Rheumatologist • Cardiologist • Cardiac surgeon • General surgeon • Oncologist • Urologist • Ophthalmologist • Otorhinolaryngologist • General physician • Family physician	• Speech pathologist • Psychologist • Biomedical engineer • Horticultural therapist • Play and Drama Therapist • Music therapist	• Employment agencies • Industries • Banks and funding agencies • Nongovernmental organizations • Community • Family members		
	c)	**Define prosthesis and orthosis.** **Ans:** **Prosthesis:** Prosthesis is a medical device designed to substitute or replace a particular body part to help patients regain certain functions after a body part has been severely injured due to an accident or disease. **Orthosis:** An orthosis is a mechanical device fitted to the body to maintain it in an anatomical or functional position.		**01** M **01** M
	d)	**Give any two functions of mobility aids.** **Ans: Functions of mobility aids are given below:** 1. To improve balance 2. To give proprioception 3. To decrease pain 4. To reduce weight bearing on injured or inflamed structures 5. To compensate for weak muscles 6. To scan the immediate environment (for the visually impaired) 7. To indicate to the bystanders of the disability of the individual (e.g. the white cane with a red tip indicates the user is visually impaired).		**02** M **(Any two)**
	e)	**Draw a labelled diagram of a prosthetic hand.** **Ans:**  **Fig. 8.1:** Basic upper limb prosthesis **OR**  **OR**		**02** M

		 **(Consider any relevant diagram)**	
	f)	**Give any two advanced applications of rehabilitation engineering.** **Ans:** 1. Hierarchically controlled prosthetic hand. 2. An intelligent prosthetic knee 3. Self alighting orthotic knee joint. 4. Electric power wheelchair 5. Myoelectric prosthesis	**02** M **(Any two)**
	g)	**Give classification of prosthesis on the basis of its functions.** **Ans:** **Classification of prosthesis** 1. Exoskeletal 2. Endoskeletal. **OR** 1. Purely cosmetic hands 2. The body powered (conventional) or externally powered, like the myoelectric hand.	**02** M
2		**Attempt any <u>THREE</u> of the following:**	**12** Marks
	a)	**Give classification of orthosis based on the basis of functions and anatomical area.** **Ans:** **Classification of orthosis based on functions** • Supportive • Corrective • Protective • Prevent substitution of function • Strengthen certain groups of muscles • Relief of pain • The Prevent weight bearing **Classification of orthosis based the anatomical area** • Cervical Orthosis • Head-Cervical Orthosis (HCO) • Head-Cervical-Thoracic Orthosis (HCTO) • Sacral Orthosis • Lumbo-sacral Orthosis (LSO) • Thoraco Lumbo-sacral Orthosis (TLSO) • Upper Extremity Orthosis ➢ Shoulder and Arm Orthosis	**02** M

		➢ Elbow Orthosis ➢ Wrist Orthosis ➢ Hand Orthosis • Lower Extremity Orthosis ➢ Foot Orthoses (FO) ➢ Ankle-Foot Orthoses (AFO) ➢ Knee-Ankle Foot Orthoses (KAFO) ➢ Hip-Knee-Ankle ➢ Foot Orthoses (HKAFO)	**02** M
	b)	**Draw a labelled sketch of self alighting orthotic knee joint.** **Ans:**  The problem caused by misplacement of single –axis orthotic joint (a) is overcome by an orthosis (b) with a self –aligning axis.	**04** M
	c)	**Describe joint angle measurement technique using Goniometer.** **Ans:** • Place the joints in a zero starting position and stabilize proximal joint component • Move joint to end of range of motion (to assess quality of movement) • Determine end-feel at point where measurement will be taken (at end of available range of motion) • Identify and palpate bony landmarks • Align goniometer with bony landmarks while holding joint at end of range • Read the goniometer • Record measurement (e.g. elbow flexion = 130^{o})	**02** M

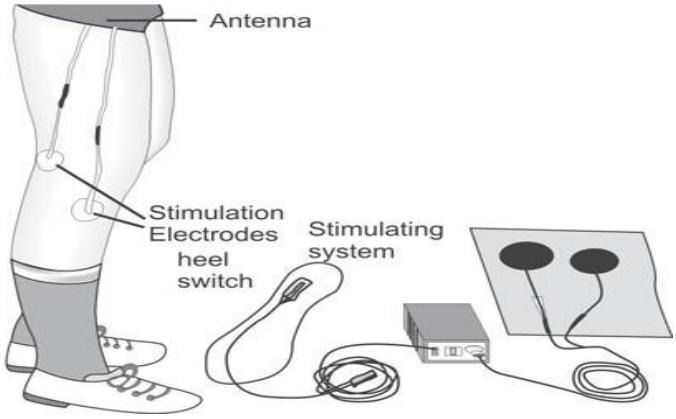
		 Flexion	**02** M
	d)	**Draw labelled structure of crutches and tripods.** **Ans:**  **Crutches**  **Tripod.**	**02** M **02** M
3		**Attempt any <u>THREE</u> of the following:**	**12** Marks
	a)	**Explain the structure and concept of Jaipur Foot.** **Ans:** The Jaipur Foot, also known as the Jaipur Leg, is a rubber-based prosthetic leg for people with below-knee amputations. It allows the amputee to walk barefoot. However, the amputee can, as an option, wear a shoe on the Jaipur Foot. It is made of waterproof and durable rubber material generally used in tyre manufacturing. It allows a good range of motion is possible. The Jaipur Foot is made of polyurethane, which at the time was the newest material used in the production of the prostheses. This works well even on rural uneven roads, muddy farming fields, allows squatting and helps in sitting on ground. The user does not need a shoe to use. Since it looks as natural	**02** M

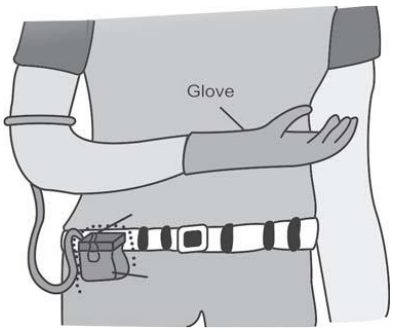
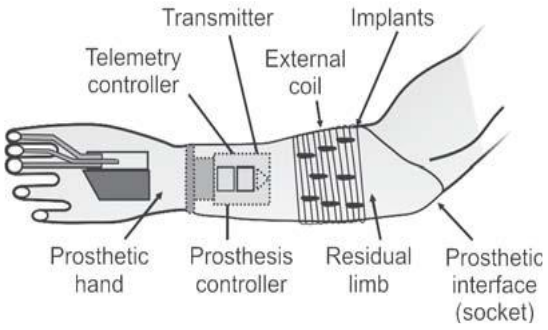
		foot , the user can easily perform social and religious activities without removing artificial limb. Due to these qualities of jaipur foot, many amputees prefer jaipur foot.  **Fig. 12.3:** Present Jaipur foot	**02** M
	b)	**Distinguish between sensory and motor rehabilitation.** **Ans:** **Sensory rehabilitation** / **Motor rehabilitation** 1. Sensory is the rehabilitation which is done to restore the functions of five traditional senses either through augmentation or via sensory substitution system. / 1. Motor rehabilitation is done to overcome the limitations in mobility which can severely restrict the quality of life of individuals. 2. Eyeglasses and hearing aids are examples of augmentative devices that can be used if some residual capacity remains. / 2. A wheelchair is a prime example of a prosthesis that can restore personal mobility to those who cannot walk. 3. Cochler implant is also an option if deafness is brought about by damage to cochlea. / 3. Loss of limb can greatly impair functional activity. Artificial or prosthetic limb is another option for motor rehabilitation	**04** M **(Any two)**
	c)	**Enlist different approaches for delivering the specified rehabilitation care.** **Ans: The delivery of rehabilitation care is done through the following approaches:** 1. Institution based rehabilitation (IBR) 2. Homes 3. Day care centers (DCC) 4. Outpatient clinics (OP) 5. Camps 6. Community based rehabilitation (CBR) 7. Inpatient rehabilitation centers.	**04** M **(Any four)**
	d)	**Draw a diagram of walking frames** **Ans:**  **Standard walking frame** **Reciprocal walking frame** **Rollator**	**04** M **(Any one)**

4		**Attempt any THREE of the following:**	**12** Marks
	a)	**Explain structure and application of walking stick and walking frames.** **Ans:** **Walking Stick:** This ubiquitous appliance is seen in almost every household. Walking sticks take away the body weight from the lower limb during walking and therefore can compensate for muscle weakness and relieve pain in the legs. In addition the use of a walking stick or sticks can increase the stability and the confidence of a patient. However, the stability is not as much as the quadripod or tripod. **Walking Frames:** Walking frames or walkers are more stable than the others because their bases are quite large and the centre of gravity falls within the base. They are prescribed for debilitated or elderly people who are usually confined to home, unable to climb stairs, and who have been advised not to venture outdoors. A patient is not usually given a walking frame unless he is not able to walk even with walking sticks, or crutches, as the pattern of gait acquired in a walking frame is difficult to change.	**02** M **02** M
	b)	**Describe any four characteristics of good prosthesis.** **Ans: Characteristics of good prosthesis are given below:** 1. It should be better Suspension – how the socket will join and fit to the limb. 2. It should be cosmetic to look at. 3. It should be comfortable to wear. 4. It should be cost effective. 5. It should be biocompatible. 6. It should be preferably be light weight 7. It should be durable. 8. Rotation – ease of changing direction 9. **Weight bearing**.-For lower-limb prostheses, the weight-bearing characteristics of the socket are the first concern. If the patient has scarring, neuromas, or sensitive areas, specific provisions must be made in the design of the socket. Special impact-absorbing materials may be used, or modifications may be necessary to spread the load over a greater area. 10. **Activity level.-**A person using the prosthesis only indoors obviously presents different considerations from someone who anticipates being active in his job and in competitive sports. Activity level influences weight bearing, suspension, and structural strength of the prosthesis. 11. **Prosthetic components**.-Components need to be matched with the amputee's activity level, body weight, and functional goals. Obviously, the person with good strength and balance does not require a stance-control knee, while someone who intends to compete in the Boston marathon would require an artificial foot designed for a high activity level.	**04** M **(Any four)**
	c)	**Distinguish between manual wheel chair and electric powered wheel chair.** **Ans:**	**04** M **(Any two)**

Electric power wheel chair	Manual wheel chair
Much heavier and harder to transport	Easy to transport
More expensive to purchase and service	Less expensive to purchase and service
Power seat adjustment	It does not have power adjustment
Ideal for those with limited or no upper body strength	Ideal for short-term use
It covers longer distances without getting tired.	Could be hard to reach a good speed when travelling longer distances

	d)	**Define and classify lever system with one anatomical example of each.** **Ans: Definition :** Lever is a length of solid materials that is use to apply force to another object **OR** Rigid structure that rotates around a fixed point **OR** Bones, ligaments, and muscles are the structures that form levers in the body to create human movement. In simple terms, a joint (where two or more bones join together) forms the axis (or fulcrum), and the muscles crossing the joint apply the force to move a weight or resistance. Levers are typically labeled as first class, second class, or third class. All three types are found in the body, but most levers in the human body are third class. A first-class lever has the axis (fulcrum) located between the weight (resistance) and the force First-class levers in the human body are rare. One example is the joint between the head and the first vertebra (the atlanto occipital joint).The weight (resistance) is the head, the axis is the joint, and the muscular actions (force) come from any of the posterior muscles attaching to the skull, such as the trapezius. In a second-class lever, the weight (resistance) is located between the axis (fulcrum) and the force. In the human body, an example of a second-class lever is found in the lower leg when someone stands on tiptoes. The axis is formed by the metatarsophalangeal joints, the resistance is the weight of the body, and the force is applied to the calcaneus bone (heel) by the gastrocnemius and soleus muscles through the Achilles tendon. In a third-class lever, the most common in the human body, force is applied between the resistance (weight) and the axis (fulcrum). There are numerous third-class levers in the human body; one example can be illustrated in the elbow joint. The joint is the axis (fulcrum). The resistance (weight) is the forearm, wrist, and hand. The force is the biceps muscle when the elbow is flexed.	**01** M **01** M **01** M **01** M
	e)	**Explain the concept of interrupted light photography.** **Ans:** Interrupted light photography is the method of motion analysis technique. Interrupted light photography to record the effect of changes in the poise of the head upon patterns of movement and posture in man. In this techniques different placements for the lights with different rates and direction. The time taken for the movement can be determined by knowing the rate at which the light source is being interrupted and by counting the number of dots. Photography is all about stopping motion, capturing split seconds in time.	**04** M
5		**Attempt any <u>TWO</u> of the following:**	**12** Marks
	a)	**Describe the concept of FES (Functional Electrical Stimulation) in detail.** **Ans:** The concept of FES was introduced by Liberson and co-workers to control foot drop during the swing phase in hemiplegic patients. Such stimulation is done to obtain a functional movement, such as picking up objects or walking. Multichannel stimulators are being used for paraplegics in research laboratories, to simulate walking. A typical functional stimulator consists of: • Stimulator • Leads • Electrodes which may be superficial or implanted. A miniature electrical stimulator producing currents between 90 and 200 mA, of pulse duration between 20 and 300 microseconds, and voltage between 50 to 120 V is fitted to the	**04** M

		patient. It must be light in weight and portable. A power pack which powers the stimulator is worn on a waist belt and in the typical peroneal stimulator, one skin electrode is applied to the common peroneal nerve below the fibular head on the affected side, while the inactive electrode is applied to the leg at the motor point of the tibialis anterior. A heel switch is incorporated in the shoe that turns on the stimulator when the heel leaves the ground and turns it off on heel strike. Thus at heel off the tibialis anterior and other dorsiflexors are stimulated, affording clearance, and at heel strike the stimulation is switched off, allowing the foot to become plantigrade. Sometimes electrodes are surgically implanted instead of being placed directly on the skin. This eliminates the need for wires passing all over the affected site. When an implanted electrode is used, it must be placed directly on the nerve with a flexible wire lead connected to a subcutaneously implanted receiver located over the antero-medial aspect of the thigh. There is an antenna located over the implanted receiver, responding to signals from a transmitter incorporated into the shoe. Phasing of the stimulation during the gait cycle is controlled by the heel switch. The power pack for the stimulator and transmitter is worn at the waist.  **A functional electrical stimulator**.	**02** M
	b)	**Describe designing aspect of intelligent prosthetic knee.** **Ans:** • The control of an artificial lower limb turns out to be most problematic during the swing phase, during which the foot is lifted off the ground to be guided into contact ahead of the walker. • A prosthetic lower limb needs to be significantly lighter than its normal counterpart because the muscular power is not present to control it. Two technological advances have helped. First, carbon fiber construction has reduced the mass of the lower limb, and second, pneumatic or hydraulically controlled damping mechanisms for the knee joint have enabled adjustment of the swing phase to suit an individual's pattern of walking. • Swing-phase control of the knee should operate in three areas: ➢ Resistance to flexion at late stance during toe-off controls any tendency to excessive heel rise at early swing. ➢ Assistance to extension after midswing ensures that the limb is fully extended and ready for heel strike. ➢ Resistance before a terminal impact at the end of the extension swing dampens out the inertial forces to allow a smooth transition from flexed to extended knee position. • In a recent advance, intelligence is built into the swing-phase controller to adjust automatically for cadence variations.	**06** M

		• A 4-bit microprocessor is used to adjust a needle valve, via a linear stepper motor, according to duration of the preceding swing phase. • The unit is programmed by the prosthetist to provide optimal damping for the particular amputee's swing phase at slow, normal, and fast walking paces. Thereafter, the appropriate damping is automatically selected for any intermediate speed.	
	c)	**Suggest designing criterion of walking aids for mentally impaired patients.** **Ans:** • It should be facilitate transfers. • It should be facilitate proper positioning. • It should be permit transportation of objects, in the wheelchair • It should be overcome architectural barriers. • It should be controlled by three ways, eye movement, voice recognition and joystick. • It should be provide appropriate seating and postural support without compromising strength, durability and safety. • It should be easily turned into a semi sleeper mode in order for the patient to feel more comfortable and thereby reduce the continuous one mode sitting problem.	**06** M **(Any six)**
6		**Attempt any <u>TWO</u> of the following:**	**12** Marks
	a)	**Describe structure and applications of myoelectric prosthesis.** **Ans:** A myoelectric prosthesis uses signals or potentials from muscles through electromyography, within a persons stump. The signals are picked up by electrodes on the surface of the skin which activates a battery-driven motor that operates a prosthetic component, like the finger. Control of the motor regulates the extent or speed of the prosthesis, such as elbow flexion or extension, or opening and closing of the fingers of the terminal device.  **OR**  **Applications:** The myoelectric prosthesis provides more mobility, pinch force, and cosmetic appearance than body powered prostheses. It eliminates the shoulder harness and more accurate control with less energy expenditure.	**04** M **02** M
	b)	**Explain design of basic structured components of wheel chair.** **Ans:** Wheelchairs differ in design and construction based on the needs of individuals and their disabilities. Wheelchairs come in three sizes: adult, child and tiny tot. Basic components / parts of wheel chair are given below: **Frames**: Wheelchair frames are either rigid or folding. The type of frame affects the maneuverability of the chair. A rigid frame in one solid piece is lighter and used more for sports and other rugged activities. A folding frame is heavier and requires more effort to maneuver but is more convenient for storage in the home and for placing into the car while	

travelling since it occupies much less space.

Tyres: The selection of tyres depends on the use of the chair. Tyres made with solid, hard polyurethane and having a smooth tread are designed for indoor use, allowing for easy maneuverability on smooth surfaces. If used outdoors these tyres offer no shock absorption or traction. Pneumatic (air filled) tyres provide for shock absorption and a smooth ride, particularly outdoors on uneven or rough terrain. These tyres require more effort to maneuver and add slightly to the overall width of the chair. Greater tread depth and lower tyre pressure provide more traction but require more effort to propel the chair.

06 M

Wheels: Two types of wheels are available: solid magnesium and with spokes

i. Solid magnesium wheels never lose their shape or need adjustments.

ii. Spoked wheels are lighter and therefore easier to manoeuvre. The disadvantage of spoked wheels is that the spokes are easily broken and will cause the wheel to lose its shape. They must therefore be tightened frequently.

Wheel sizes may vary depending on the size and weight of the user. There are two sizes- 12″ and 18″ diameter. A smaller wheel size requires more pushing strokes than a larger wheel size to propel the chair over the same distance. A small wheel reduces height to the wheelchair during transfers.

Brakes: There is a separate brake for each wheel of the chair. Brakes must be put on when stopping the chair, whenever the person is being transferred in or out of the chair, or whenever a procedure like standing up in the wheelchair, or eating from a tray placed on it is contemplated.

Casters: There are 2 casters in front of the wheels. They are different from wheels in that they can revolve in all directions, and allow for better front end maneuverability on smooth surfaces. Casters are pneumatic, semi pneumatic, or solid. The semi pneumatic type is better on uneven terrain. Pneumatic casters provide for greater shock absorption; however, there is an increased drag during propulsion if not filled with air properly. This increases the expenditure of energy. Solid casters are good on smooth terrain. Casters may also have locks.

Push Rims (Hand Rims): The type of push rim depends on the user's grip. There are basically three types:

• Standard metal rims,
• Friction rims, and
• Rims with projections.

Standard metal rims are used when grip is not a problem. Friction rims are standard rims covered with friction tape or foam tubing to provide additional grip on the rim surface. Projection rims are used by people with limited reach and grip, like quadriplegics. These are knobs are placed at intervals to give the user better grip and leverage for propulsion. The greater the number of knobs the greater is the facilitation for movement. Projection knobs may be either at an oblique angle or vertical. However, they may hit against the sides of the wall or furniture and add to the overall width The chair used by a hemiplegic has two hand rims on the same (unaffected) side and the user propels it using the same hand. To negotiate turns he uses either one of the hand rims.

		Footrests: Footrests maintain the feet in neutral and prevent deformities like equinus. They are either fixed or movable. Swing away footrests are more convenient but increase the length of the chair, which affects turning and maneuverability. These lack toughness and require frequent repair. Heel loops or leg straps can be added to the footplate. Either or both of these accessories add length to the wheelchair. **Tilt Bars**: Tilt bars, which project from the back of frame, usually 2 to 3 inches above the floor, are used by the individual who is pushing the wheelchair. By placing the foot on the tilt bar and pushing down with the foot, the person can tilt the wheelchair back, allowing the casters to rise off the surface, thus enabling them to clear a doorstep or kerb. This can also be done by doing what is called a 'wheelie', which is the same action as above, done by the wheelchair user himself. **Backrests**: High wheelchair backs provide trunk support and are ideal for a high level quadriplegic or a child with cerebral palsy with poor sitting balance. Low chair backs provide a greater freedom for movement and are preferred by individuals with low level spinal cord lesions and by those who participate in sporting activities. The angle of chair backs can be changed and many wheelchairs have their backrests detachable, permitting a back transfer. Chest straps are provided to the back rest when sitting balance is poor. **Armrests**: Removable armrests are convenient, provide support, and make transferring easier when detached. Armrests can also be fixed or adjustable in height and may be partial length or full length. However, they restrict movement during propulsion. Environment control units, keyboards, books or trays can be placed on these armrests. **Foldability:** Many wheelchairs are lightweight, foldable and modular, which makes it convenient to transport it in buses, trains or cars. The seats in such wheelchairs are usually canvas. **Seats:** Patients come in all sizes and it makes sense to take the measurements for the seat, so that he is most comfortable. The dimensions to be taken into consideration are the seat height, depth and width. **Cushions**: Cushions are used to achieve the most comfortable and supportive position possible and sometimes can make all the difference in the prevention of a secondary disability like pressure sore. Seat cushions may be air-filled, gelinsert, contour foam, or gel filled. Some have individual inflatable air cells, which are available in varying thicknesses and can be customized for posture control and pressure relief. **Head-rest:** It is prescribed for those who have no head control, and have primitive neck reflexes. It is also detachable. **Clothes Guard:** This prevents loose fitting clothes from getting entangled in the wheels. **Anti-tip Bars:** Anti-tip bars keep the chair from tipping too far backward. They are used primarily by new users and by those with a high-level spinal cord injury.	
	c)	**Define Gait cycle and explain various phases of gait cycle with neat diagram.** **Ans:** The gait cycle is a series of documented movements during walking which by convention is measured from the point of initial heel contact of one lower extremity to the same point when it occurs again, that is the point at which the heel of the same extremity contacts the ground again.	**02** M

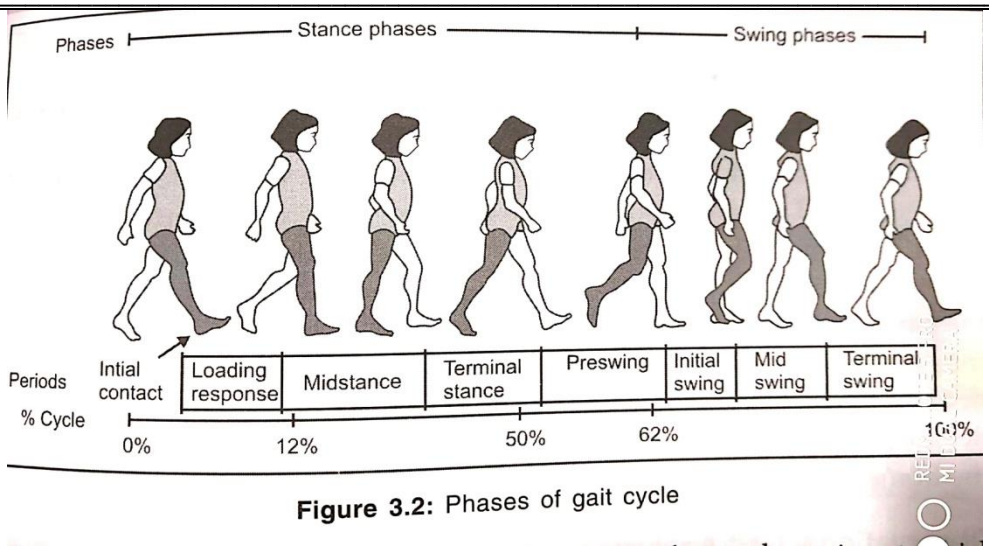


Figure 3.2: Phases of gait cycle

02 M

The two main phases of gait cycle:

1. The stance phase
2. The swing phase

1. **Stance Phase:** The stance phase occupies 60% of the total gait cycle, during which some part of the foot is in contact with the ground. It is further divided into five sub-phases:

i. Initial contact (heel strike)
ii. Loading response (foot flat)
iii. Mid-stance
iv. Terminal stance (heel off)
v. Pre-swing (toe off)

02 M

2. **Swing Phase:** The swing phase occupies 40% of the total gait cycle, during which the foot is not in contact with the ground and the bodyweight is borne by the other leg and foot. It is further divided into three sub-phases:

i. Initial swing
ii. Mid-swing
iii. Terminal swing