WINTER – 2019 EXAMINATION

Subject Name: Rehabilitation Engineering **Model Answer** **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.

Q. No.	Sub Q. N.	Answer	Marking Scheme
1.		**Attempt any <u>FIVE</u> of the following:**	**10 M**
	a	**Enlist various steps of gait cycle.** **Ans:** **Various steps of gait cycle:** 1. Initial Contact 2. Loading Response 3. Mid stance 4. Terminal Stance 5. Pre swing 6. Initial Swing 7. Mid Swing 8. Late Swing	**02 M (Any four)**
	b	**Give any two goals of rehabilitations engineering.** **Ans:** **Goals of rehabilitations engineering:** 1. Orientation 2. Physical independence 3. Mobility 4. Occupational integration 5. Social integration 6. Economic self- sufficiency	**02 M**
	c	**Define prosthesis and orthosis.** **Ans:** **Definition of prosthesis and orthosis:** **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**

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<td>
Draw a labelled diagram of a prosthetic hand.
Ans:

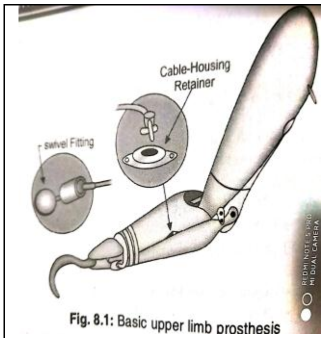
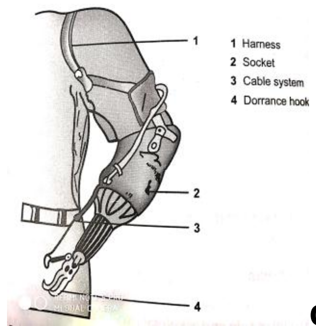


Fig. 8.1: Basic upper limb prosthesis

OR



OR

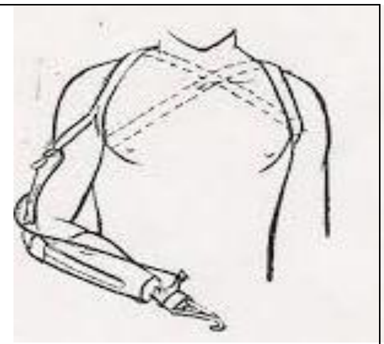


Fig: Prosthetic hand
(Consider any relevant diagram)
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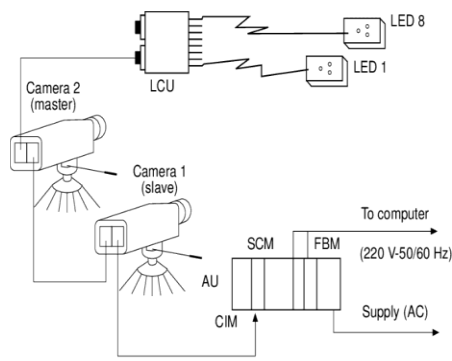
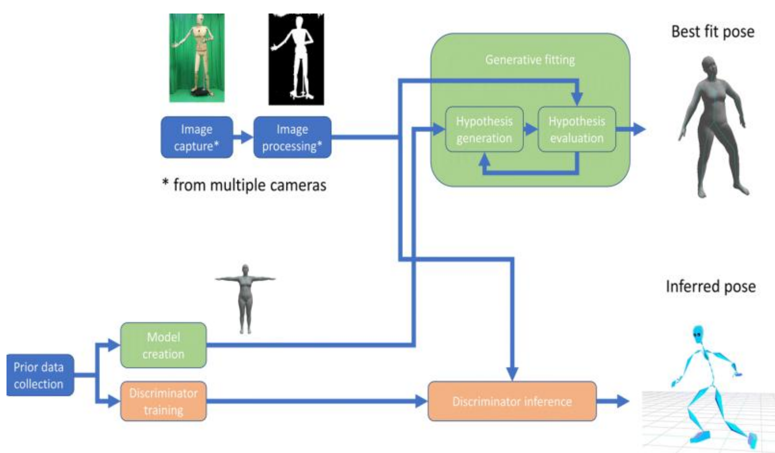
Draw labelled diagram of any one motion analysis technique.
Ans:
Motion analysis technique:

OR



Selspot technique



Film / video technique
(Consider any relevant diagram)
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Give any two functions of mobility aids.
Ans:
Functions of mobility aids:
1. To improve balance
2. To Give Proprioception
3. To Decrease Pain
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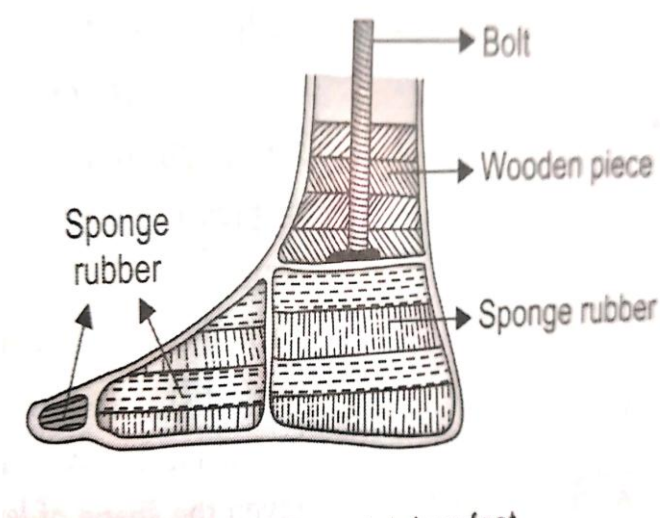
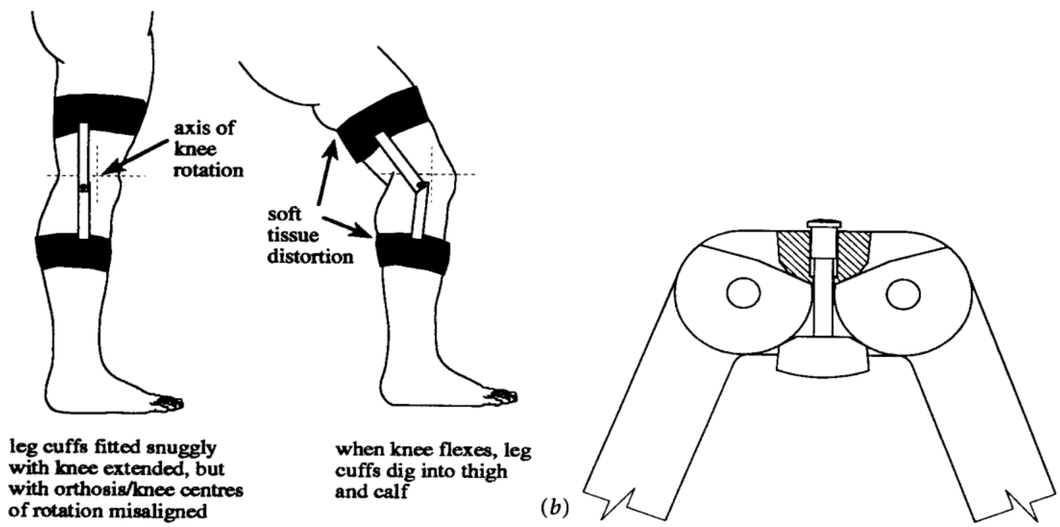
		4. To Reduce Weight Bearing On Injured Or Inflamed Structures 5. To Compensate For Weak Muscles 6. To Scan The Immediate Environment (For The Visually Impaired) 7. To Indicate to the bystanders of the disability of the individual (e.g. the white cane with a red tip indicates the user is visually impaired).	02 M
2.		**Attempt any THREE of the following:**	**12 M**
	a	**Describe the maintenance steps of the specified mobility aid.** **Ans:** **Wheelchair Maintenance steps:** 1. The wheelchair should be cleaned regularly. 2. Soap water and wax should be used on the painted surfaces. 3. One should check whether the wheels run parallel in a straight line. 4. Oil may be used for all movable parts except bearings for lubrication. 5. Nuts and bolts must be tightened. 6. Metal parts should be sprayed and wiped clean, followed by application of polish. 7. The upholstery should be cleaned. 8. Telescoping parts like footrests should be polished. 9. Tyre pressure should be checked; Low pressure in the tyres will damage rims and make the chair more difficult to propel. 10. As spokes keep the wheel shape patent, they should be tightened periodically and replaced immediately if broken. 11. Bearings in the wheel and caster should be checked for freedom of spin and smoothness. 12. Once every 6 months, the wheelchair should have a complete overhaul by the manufacturer, particularly if used outdoors. **Crutch Maintenance steps:** 1. The wood or metal must be strong enough to take the patient's weight 2. The catches used for height adjustments must be functional. 3. The rubber ferrules must be in good condition. 4. The handgrips and axillary pads must be in good condition. 5. All the adjusting nuts must be tight. **(Consider any relevant maintenance steps)**	**04 M**
	b	**Describe with sketch, process of the specified joint angle measurement.** **Ans:**  Flexion **Fig: joint angle measurement**	**02 M**
		1. Position joint in zero position and stabilize proximal joint component 2. Move joint to end of range of motion (to assess quality of movement) 3. Determine end-feel at point where measurement will be taken (at end of available range of motion)	**02 M**

		4. Identify and palpate bony landmarks 5. Align goniometer with bony landmarks while holding joint at end of range 6. Read the goniometer 7. Record measurement (e.g. elbow flexion = 130^o)	
	c	**Draw labelled structure of crutche's and tripod's.** **Ans:**  **Fig: Structure of crutche's and tripods**	**04 M**
	d	**Explain structure and function of a Jaipur foot.** **Ans:** **Structure and function of a Jaipur foot:** 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 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	**04 M**

3.		**Attempt any THREE of the following:**	**12 M**
	a	**List different approaches for delivery of rehabilitation care.** **Ans:** **Approaches for delivery of rehabilitation care:** 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)**
	b	**Draw a labelled sketch of self alighting orthotic knee joint.** **Ans:** **Self alighting orthotic knee joint:**  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	**Discuss the concept of sensory rehabilitation.** **Ans:** **Concept of sensory rehabilitation:** Sensory is the rehabilitation which is done to restore the functions of five traditional senses either through augmentation or via sensory substitution system. The two senses: vision and hearing are the main input channel through which data with high information content can flow. A loss of one or the other of these senses (or both) can have a devastating impact on the individual affected. Rehabilitation engineers attempt to restore the functions of these senses either through augmentation or via sensory substitution systems. Eyeglasses and hearing aids are examples of augmentative devices that can be used if some residual capacity remains. A major area of rehabilitation engineering research deals with sensory substitution systems.	**04 M**
	d	**Describe various wheelchairs standard's and test.** **Ans:** **Wheelchairs standard's and test:** A wheelchair is a chair with wheels, used when walking is difficult or	

		impossible due to illness, injury, or disability. Wheelchairs come in a wide variety of formats to meet the specific needs of their users. They may include specialized seating adaptions, individualized controls, and may be specific to particular activities, as seen with sports wheelchairs and beach wheelchairs. The most widely recognized distinction is between powered wheelchairs ("powerchairs"), where propulsion is provided by batteries and electric motors, and manually propelled wheelchairs, where the propulsive force is provided either by the wheelchair user/occupant pushing the wheelchair by hand ("self-propelled"), or by an attendant pushing from the rear ("attendant propelled"). Wheelchairs come in three sizes: adults, child and tiny tot. **Testing procedure:** 1. The wheelchair should be cleaned regularly. 2. Soap water and wax should be used on the painted surfaces. 3. One should check whether the wheels run parallel in a straight line. 4. Oil may be used for all movable parts except bearings for lubrication. 5. Nuts and bolts must be tightened. 6. Metal parts should be sprayed and wiped clean, followed by application of polish. 7. The upholstery should be cleaned. 8. Telescoping parts like footrests should be polished. 9. Tyre pressure should be checked; Low pressure in the tyres will damage rims and make the chair more difficult to propel. 10. As spokes keep the wheel shape patent, they should be tightened periodically and replaced immediately if broken. 11. Bearings in the wheel and caster should be checked for freedom of spin and smoothness.	**04 M**
4.		**Attempt any <u>THREE</u> of the following:**	**12 M**
	a	**Describe the concept of hierarchically controlled prosthetic hand.** **Ans:** **Concept of hierarchically controlled prosthetic hand:** Control of the intact hand is hierarchical. It starts with the owner's intention, and an action plan is formulated based on knowledge of the environment and the object to be manipulated. For gross movements, the numerous articulations rely on "preprogrammed" coordination from the central nervous system. Fine control leans heavily on local feedback from force and position sensors in the joints and tactile information about loading and slip at the skin. In contrast, conventional prostheses depend on the conscious command of all levels of control and so can be slow and tiring to use. Current technology is able to provide both the computing power and transducers required to recreate some of a normal hand's sophisticated proprioceptive control. A concept of extended physiologic proprioception (EPP) was introduced for control of gross arm movement whereby the central nervous system is retrained through residual proprioception to coordinate gross actions applying to the geometry of the new extended limb. This idea can be applied to initiate gross hand movements while delegating fine control to an intelligent controller. The controller coordinates the transition between these positions and ensures that trajectories do not tangle. Feedback to the controller is provided by several devices. Potentiometers detect the angles of flexion of the digits; touch sensors detect pressure on the palmer surfaces of the digits; and a combined contact force (Hall effect) and slip sensor (from acoustic frequency output of force sensor) is mounted at the fingertips. The latter detects movement of an object and	**04 M**

so controls grip strength appropriate to the task–whether holding a hammer or an egg. The whole hand may be operated by electromyographic signals from two antagonistic muscles in the Supporting forearm stump, picked up at the skin surface. In response to tension in one muscle, the hand opens progressively and then closes to grip with an automatic reflex. The second muscle controls the mode of operation as the hand moves between the states of touch, hold, squeeze, and release.

b **Distinguish between electric powered wheelchair and manual wheelchair.**

Ans:

Electric powered wheelchair	Manual wheelchair
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

Table: Electric power wheelchair and manual wheelchair

04 M (Any two)

c **Describe knee joint prosthesis with neat sketches.**

Ans:

Knee joint prosthesis:

The basic purpose of the prosthetic knee is provide stability and controlled movement for ambulation as shown in fig. The knee joint is aligned in the prosthesis with the client's knee in extension. The best knee mechanism is one that offers adequate stability in stance phase, yet requires the least amount of alignment. In some cases, if the knee mechanism does not fully extend before heel contact, it buckles causing the prosthetic knee to flex suddenly when weight is applied.

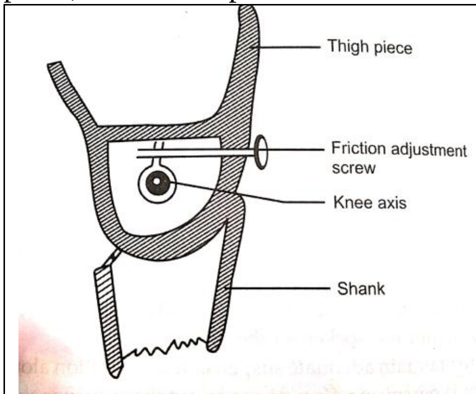
The term stance phase control refers to the degree of stability when standing on the prosthesis. It is most important during single limb support when standing on the prosthetic limb. An inter play of forces and alignments between knee mechanism and the foot designing decides the stance phase control of most conventional A/K prostheses.

02 M

Knee mechanisms can be classified into:

- Constant friction
- Stance control
- Polycentric knee
- Manual locking (rare)
- Fluid controlled

For the foot to be in proper position for heel contact, the knee mechanism must exert some control over the rate of knee movement in swing phase. This is referred to as swing phase control. Multiaxis knee joints are usually four bar linkage systems. They are polycentric axis knees. They are complex and are used primarily for knee disarticulation prostheses. The knee axes keep changing as the person walks. This gives some swing phase control by allowing for better toe clearance. They also offer some stance phase control by varying stability through the different axes. Multiaxis systems allow knee flexion to 130°-150°. Turn tables and torque mechanisms exist that allow the individual wearing a transfemoral limb to even sit cross-legged, something that is done often in India. Pneumatic control knee mechanisms use an air filled cylinder embedded within the upper part of the shank to provide variable swing phase control. The manual lock knee provides absolute stance phase control as the knee remains locked and stiff in extension throughout the gait cycle. They are occasionally used for individuals with bilateral amputations or those occupations that may require considerable standing in one

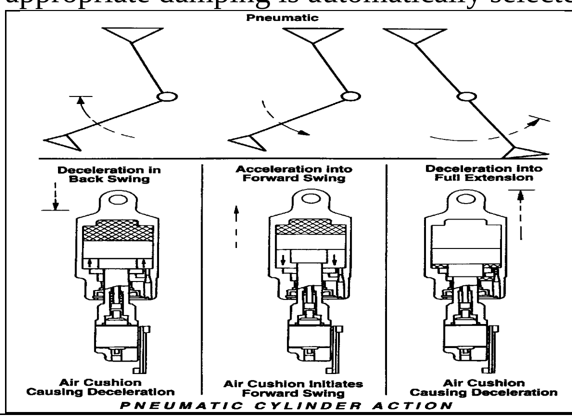
		place, like traffic policemen.  **Figure 8.32:** Constant friction knee joints **OR**  **Fig. 6.19:** Knee joint assembly **Fig: Knee joint prosthesis** (Consider any relevant diagram)	**02 M**
	d	**Define anatomical lever system with each of example.** **Ans:** **Anatomical lever system:** Bones, ligaments, 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 An example of a first-class lever is a pair of pliers or scissors. First-class levers in the human body are rare. One example is the joint between the head and the first vertebra (the atlantooccipital joint).The weight (resistance) is the head, the axis is the joint, and the muscular action (force) comes 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 .The most obvious example is a wheelbarrow, where a weight is placed in the bed of the wheelbarrow between the wheel (axis) and the hands of the person using the wheelbarrow (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) . Picture someone using a shovel to pick up an object. The axis is the end of the handle where the person grips with one hand. The other hand, placed somewhere along the shaft of the handle, applies force. At the other end of the shovel (the bed), a resistance (weight) is present. 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.	**04 M**
	e	**Describe with sketches an intelligent prosthetic knee.** **Ans:** **An intelligent prosthetic knee:** 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:

1. Resistance to flexion at late stance during toe-off controls any tendency to excessive heel rise at early swing.
2. Assistance to extension after midswing ensures that the limb is fully extended and ready for heel strike.
3. 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.

02 M

In a recent advance, intelligence is built into the swing-phase controller to adjust automatically for cadence variations. 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.



02 M

5. **Attempt any <u>TWO</u> of the following:** **12 M**

a **Compare sensory and motor rehabilitation (Any three points)**

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. Cochlear 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

Table: Compare sensory and motor rehabilitation

06 M

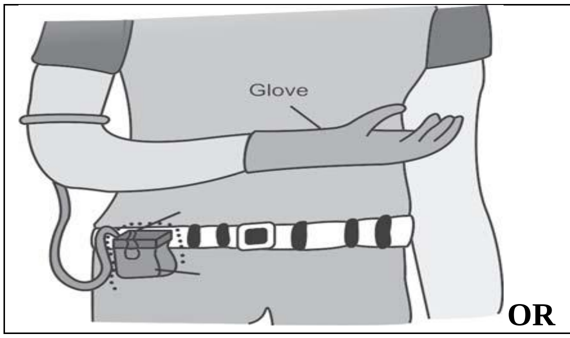
b **Describe structure and applications of myoelectric prosthesis.**

Ans:

Structure and applications of myoelectric prosthesis:

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. **02 M**

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. **02 M**



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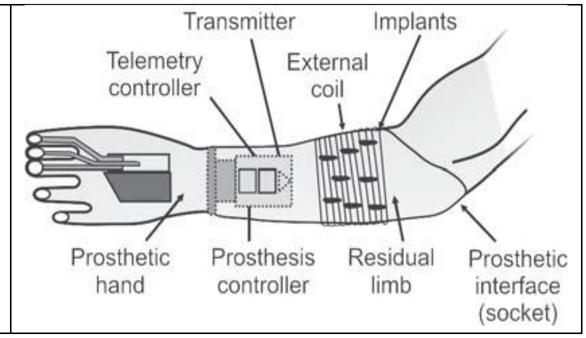


02 M

Fig: Myoelectric prosthesis

c **Define gait cycle and describe various stages of gait cycle with neat sketches.**

Ans:

Definition of Gait cycle and various stages of gait cycle:

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**

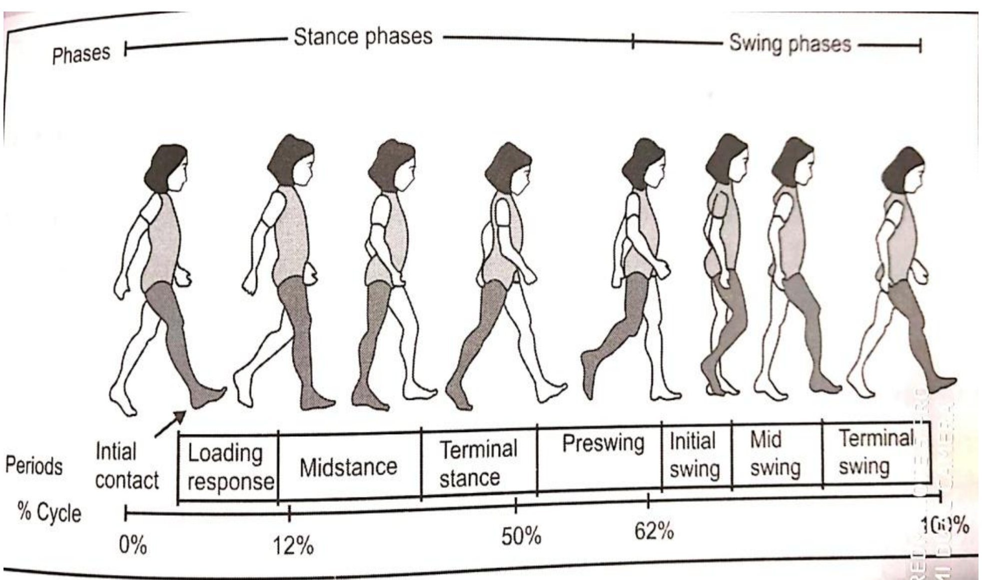


Figure 3.2: Phases of gait cycle

04 M

6.		**Attempt any <u>TWO</u> of the following:**	**12 M**

a **Describe with sketch any two techniques for motion analysis.**

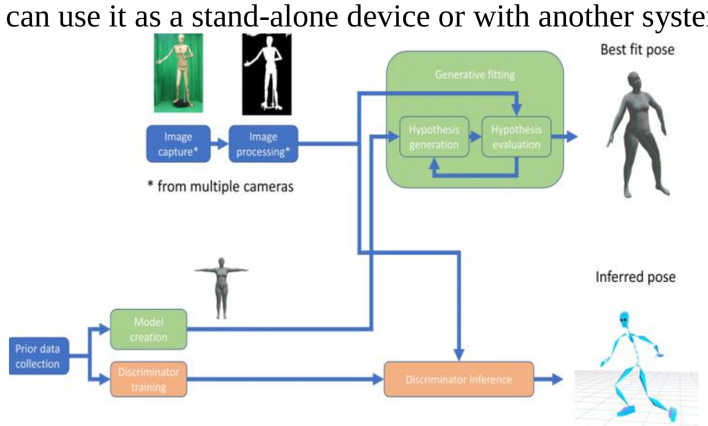
Ans:

Techniques of motion analysis:

Film /video:

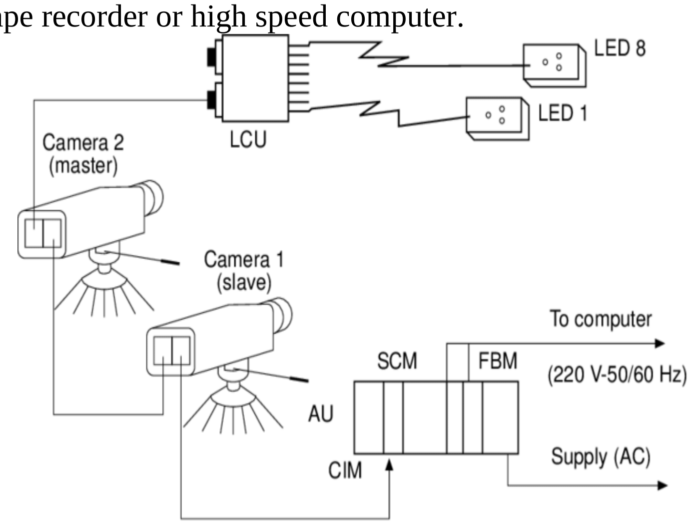
1. One of the simplest pieces of gait instrumentation is the picture video
2. A picture video helps to measure a persons gait prior to applying any instrumentation, that might alter gait pattern
3. It provides a visual documentation of what happened during instrumented test and is the only way of resolving differences when the recorded footswitches or motion data do not correspond to clinicians visual image of a subject
4. A basic video system consist of a VCR, one or two video cameras ,a character generator ,a video mixer and a TV monitor
5. The video mixer combines images from 2 cameras so that the lateral and anterior /posterior view can be observed simultaneously
6. The character generator enables to overlay text(e.g. name and date)on the video image
7. The clinician can use it as a stand-alone device or with another system.

03 M



Selspot technique which requires the subject to wear special light on each desired anatomical landmark. The lights are flashed sequentially and the location (x, y) of the light flash is picked up on a special camera. The location of the image of the light flash gives two signals, one indicating the x coordinate of the image, the other indicating the y coordinate. As each light flashes in sequence a series of x and y coordinate signals are fed to the tape recorder or high speed computer.

03 M



	b	**Describe the concept and application of functional electrical stimulation.** **Ans:** **Concept of functional electrical stimulation:** 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 patient. It must be light in weight and portable. **Application of functional electrical stimulation:** 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. Functional Electrical Stimulation also used to major hip and thigh muscle groups in patients with spinal cord injuries for muscle strengthening, maintaining standing posture and ambulation.	**04 M** **02 M**
	c	**Suggest designing criterion of walking aids for mentally impaired patient.** **Ans:** **Designing criterion of walking aids for mentally impaired patient:** 1. It should be facilitate transfers, 2. It should be facilitate proper positioning, 3. It should be permit transportation of objects, in the wheelchair 4. It should be overcome architectural barriers, 5. It should be controlled by three ways, eye movement, voice recognition and joystick. 6. It should be provide appropriate seating and postural support without compromising strength, durability and safety. 7. 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)**