Harsh Shrivastava
Roll No. : 21310011
ME 639
Introduction to Robotics
Mid sem Exam

Ques 2)

Ans)

a) Hard gripper/soft gripper

   Soft grippers will be suitable for this task
   Reasons:
   1) Soft grippers, unlike conventional mechanical devices, are made of compliant materials and are frequently powered by compressed air. I
   2) Soft grippers can handle delicate products that would be easily damaged by typical hard grippers.
   3) They can conform to surfaces or objects,
   4) Absorb energy to maintain stability,
   5) Exhibit physical robustness and
   6) Human-safe operation at potentially low cost.
   7) Internal pressure resists buckling and distributes stresses throughout the structure.

b) **Flexible mechanisms** : A flexible microactuator (FMA) driven by an electropneumatic (or electrohydraulic) system has been developed. It has three degrees of freedom-pitch, yaw, and stretch-making it suitable for robotic mechanisms such as fingers, arms, or legs. It is made of fiber-reinforced rubber, and the mechanism is very simple, enabling miniature robots without conventional link mechanisms to be designed. Serially connected FMAs act as a miniature robot manipulator.
   Applying a flexible microactuator to robotic mechanisms | IEEE Journals & Magazine | IEEE Xplore

   Soft robotic grippers : Soft gripping can be categorized into three technologies, enabling grasping by: a) actuation, b) controlled stiffness, and c) controlled adhesion. Compared to rigid grippers, end-effectors fabricated from flexible and soft components can often grasp or manipulate a larger variety of objects. Such grippers are an example of morphological computation, where control complexity is greatly reduced by material softness and mechanical compliance. Advanced materials and soft components, in particular silicone elastomers, shape memory materials, and active polymers and gels, are increasingly investigated for the design of lighter, simpler, and more universal grippers, using the inherent functionality of the materials. Embedding stretchable distributed sensors in or on soft grippers greatly enhances the ways in which the grippers interact with objects.
   Soft Robotic Grippers - Shintake - 2018 - Advanced Materials - Wiley Online Library

   Universal grippers : A gripper which replaces individual fingers by a material that upon contact molds itself around an object. It forms to any shape and is passive, which means

that all shape adaptation is performed autonomously by the contacting material and without sensory feedbacThis process reduces the number of elements to be controlled and therefore has advantages in terms of reliability, cost, and gripping speed.When the gripper needs to pick up an object, a vacuum contracts the granular material and hardens quickly to pinch and hold the object without requiring sensory feedback. Volume changes of less than 0.5% are enough to grip objects reliably and hold them with forces exceeding many times their weight. The gripper is made of a single non porouselastic bag filled with granular matter. This system gives a robotic hand an infinitely many degrees of freedom, which are actuated passively by contact with the surface of the object to be gripped. It's locked in place by a single active element, a pump that evacuates the bag. **Universal Grippers can be used for our application of Pill picking.**
Universal Robotic Gripper (wevolver.com)

Paper grippers : Soft food grasping in the food processing field is challenging for traditional robot hands because of the large demand, special hygiene cleanness and damage-free requirements. The paper-made grippers are low-cost and disposable to solve the crucial cleanness problem and they have soft structures which can adapt to the object shapes to avoid possible grasping damages. **Paper Grippers may be used for our application of Pill picking.**

Paper-Made Grippers for Soft Food Grasping | IEEE Conference Publication | IEEE Xplore

Origami Robots : Origami is an ancient Japanese paper art technique, which allows the folding of a large two-dimensional sheet into a compact volume by careful arrangement of creases.Origami robots are functional devices whose structure and dynamics are derived from the paper art techniques and can be used for aeronautical, biomedical and environmental applications. Coupled with advanced manufacturing methods, origami robots, which have tunable compliance, can provide solutions to problems which often cannot be addressed by conventional soft or hard robots
Origami Robots: Design, Materials and Applications | Frontiers Research Topic (frontiersin.org)

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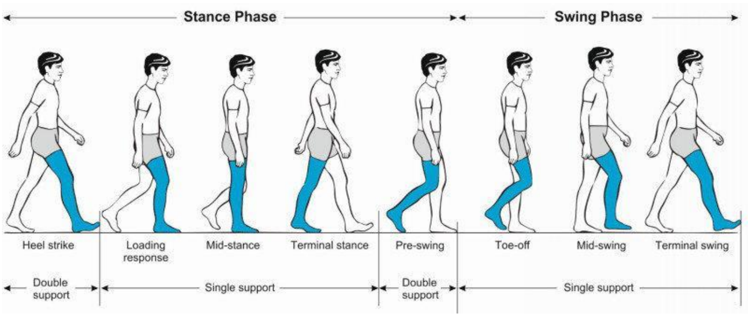
Ques 3)

Ans)

a) Let Length of first link (Hip to knee distance); L1= 0.6 m
Length of second link (Knee to ankle distance); L1= 0.55 m

Gait trajectory : Human gait may be define as " the translatory progression of the human body as a whole, produced by coordinated, rotatory movements of the body segments" is known as gait or human locomotion.

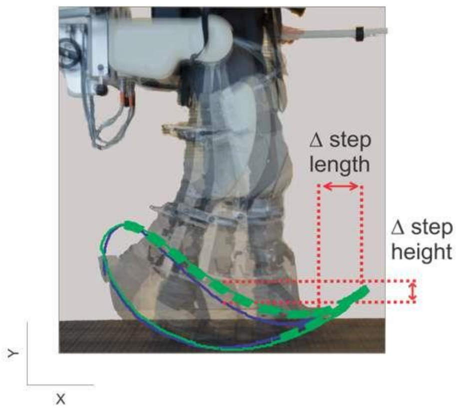
Human gait is Biped Gait. Each leg performs function alternatively. Hence, called Alternate Bipedalism. It is a Heel-Toe Gait. Heel touches the ground first followed by toes and heel leaving the ground first followed by the toes.



Step Length :

As shown in below figure it is the length measuring the distance between the steps with alternate foot.

Step Height :
As shown in below figure it is the Height raised by foot above the ground.



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Q-5)
Ans) Yes

Q-6)
Ans) No

Q-7)
Ans) Yes

Q-8)
Ans) Yes

Q-9)
Ans) yes

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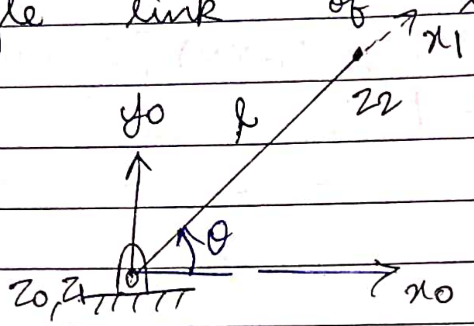
MID TERM EXAM

Q-4

Solⁿ

(a) Robot with Single Revolute joint & Single link of length 'l'.



i	α_{i-1}	a_{i-1}	d_i	θ_i
1	0	0	0	θ

α_{i-1} → angle between Z_{i-1} & Z_i

(α_0 → angle between Z_0 & Z_1 i.e. $0°$)

a_{i-1} → ~~angle~~ distance b/w Z_{i-1} & Z_i

(a_0 → distance b/w Z_0 & Z_1 i.e 0)

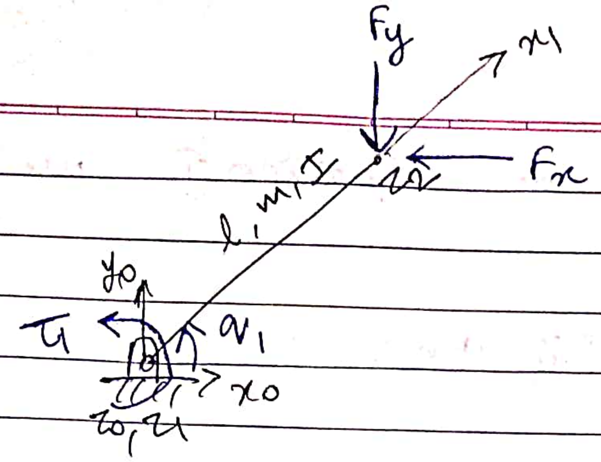
d_i → distance b/w X_{i-1} & X_i

(d_1 → distance b/w X_0 & X_1)

θ_i → angle b/w X_{i-1} & X_i

(θ_1 → angle b/w X_0 & $X_1 = \theta$)

(4)(b)



$$\tau_1 = F_y\, l \cos q_1 - F_x\, l \sin q_1$$

Lagranges Equation, $L = K - V$

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_i}\right) - \left(\frac{\partial L}{\partial q_i}\right) = \tau_i$$

For $i=1$

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_1}\right) - \left(\frac{\partial L}{\partial q_1}\right) = \tau_1 \quad \text{— (1)}$$

Now $K = \left(\frac{1}{3} m l^2\right)\frac{1}{2}\dot{q}_1^2 = \frac{1}{6} m l^2 \dot{q}_1^2$

$$V = \frac{mgl}{2}\sin q_1$$

$$L = K - V = \frac{1}{6} m l^2 \dot{q}_1^2 - \frac{mgl}{2}\sin q_1$$

$$\frac{\partial L}{\partial \dot{q}_1} = \frac{1}{3} m l^2 \dot{q}_1$$

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_1}\right) = \frac{1}{3} m l^2 \ddot{q}_1$$

$$\frac{\partial L}{\partial q_1} = -\frac{mgl}{2}\cos q_1$$

Substituting in equation (1) we get

$$\tau_1 = \frac{1}{3} m l^2 \ddot{q}_1 + \frac{mgl}{2} \cos q_1$$

Now $F_x = Kx$, $F_y = Ky$

~~From~~ also we know that

$x = l \cos q_1$, $y = l \sin q_1$

$\Rightarrow F_x = K l \cos q_1$, $F_y = K l \sin q_1$

also $\cancel{F_x}$ $F_y l_1 \cos q_1 - F_x l_1 \sin q_1 = \tau_{1s}$

$\Rightarrow \tau_{1s} = K l^2 \sin q_1 \cos q_1 - K l^2 \cos q_1 \sin q_1$

$\Rightarrow \tau_{1s} = 0$

So $\tau_d = \tau_1 + \tau_{1s}$

$$\boxed{\tau_d = \frac{1}{3} m l^2 \ddot{q}_1 + \frac{mgl}{2} \cos q_1}$$

desired torque

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(4)(c) Total energy of system, U

$$U = K + V$$
$$= \frac{1}{6} m l^2 \dot{q}_1^2 + \frac{mgl}{2} \sin q_1$$

$$U = \frac{1}{6} m l^2 \dot{q}_1^2 + mg\frac{l}{2} \sin q_1$$

total energy of system is constant