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Q2)

ANS)

a) Pills can be of varying shapes and sizes. From pellet type to cylindrical to oblong. To effectively pick up such non-standard shapes, hard grippers are not favourable as they may not provide proper traction & grip on the pill.
Compliant/Soft grippers bend around such non-standard shapes and provide much better grip & support as compared to hard grippers. One-DoF grippers rely on friction between the object and gripper to maintain grip. As friction depends on normal force, the hard grippers may apply a higher amount of force on the pill to maintain grip. This can, in many cases damage the pill that is being picked up. This is not the case with soft & compliant grippers. The bending effect gives them a huge advantage over the hard grippers that are generally used. However, designing soft/compliant grippers with a compact form factor is challenging.

b) The best one from these mechanisms would be the soft robotic grippers. Flexible, Origami & paper grippers are fine but they cannot be made in a compact form factor. Universal grippers cannot be used to pick up single pills from a cup. The suction may cause other lying pills to get stuck too. Hence Soft gripper is the best. Below is a video link that demonstrates the same.
    Universal Soft Robotic Gripper
    Another type of soft gripper that can be used for pill picking purposes is discussed in this paper: Paper Link

Q3)

ANS)

a)

First link length: 44 cm
Second link length: 40 cm

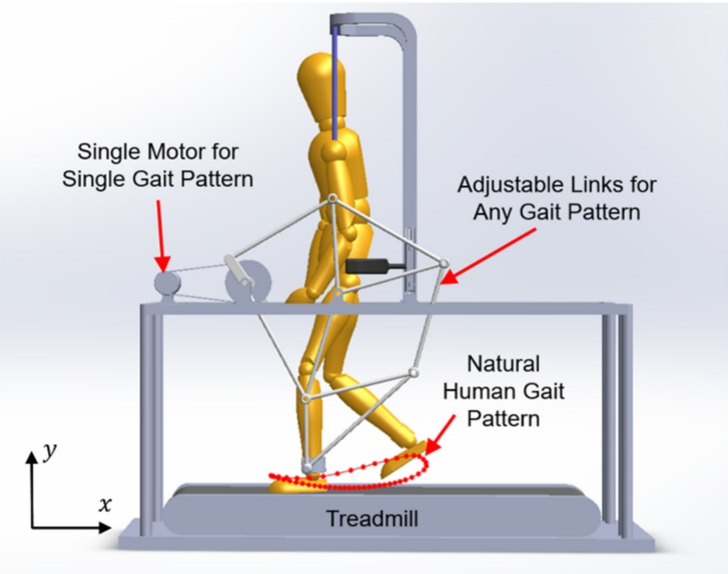
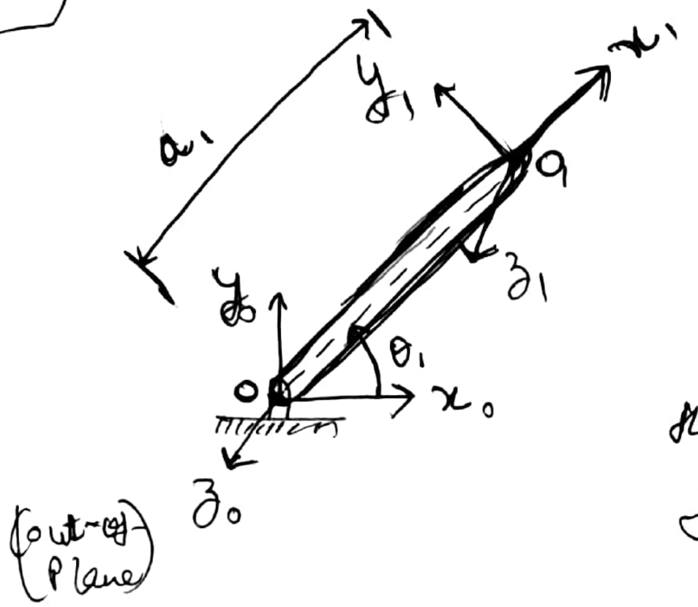


Figure 1: Gait Trajectory Study[1]

Gait Trajectory: The path followed by the ankle joint of the lower limb while walking normally is called the gait trajectory. Everyone has their own unique gait pattern and this can be tracked using various sensors to generate gait data. The gait trajectory normally has a tear drop type shape. The variations that are seen are in the maximum span of the shape in the vertical & horizontal direction.
Step height: Step height id the maximum height to which the heel of the person rises in a single gait cycle. From data, it can be obtained as:
Step height = max{y} - min{y} [in the x-y plane]
Step length: This is the horizontal span of the gait pattern in the horizontal direction [in x-y plane]. It is mathematically obtained by finding the distance covered by the ankle in the horizontal direction from the point of max height to heel strike.

Q.4)

a)



Base frame $O x_0 y_0 z_0$

For this configuration: the DH Parameters are as follows:-

	a	α	d	θ
1)	a_1	0	0	θ_1

The Rotation Matrix will be:-

$$R_0^1 = \begin{bmatrix} \cos\theta_1 & -\sin\theta_1 & 0 & a_1\cos\theta_1 \\ \sin\theta_1 & \cos\theta_1 & 0 & a_1\sin\theta_1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

(b) Since it has to behave like a torsional spring :-

$$\boxed{\tau = -k\theta_1} \quad \forall\ k \text{ is the stiffness constant.}$$

To get eqn of Motion, we can use a lagrangian approach :-

Since :

$$K = \frac{1}{6} m l^2 \dot{\theta}_1^2$$

$$P = \frac{1}{2} k\theta_1^2$$

$$\Rightarrow \quad L = K - P = \frac{1}{6} m l^2 \dot{\theta}_1^2 - \frac{1}{2} k\theta_1^2$$

$$\Rightarrow \quad \frac{d}{dt}\left(\frac{\partial L}{\partial \dot{\theta}_1}\right) - \frac{\partial L}{\partial \theta_1} = \tau$$

$$\Rightarrow \quad \frac{d}{dt}\left(\frac{1}{3} m l^2 \dot{\theta}_1\right) + k\theta_1 = \tau$$

$$\Rightarrow \boxed{\frac{1}{3} m l^2 \ddot{\theta}_1 + k\theta_1 = \tau}$$

This is the required torque.

Q5)

ANS) YES. The Z-axes are chosen such that it aligns with the respective axis of actuation. In other words, z_i will align with the Joint axis of joint i+1.

Q6)

ANS) NO. The Origins of coordinate frames is obtained by analysing the zi & zi+1 axis. When the two axes intersect, only in this case the origin is placed at the centre of joint.

Q7)

ANS) YES. True it is. That is the reason why it is called a homogeneous transformation

Q8)

ANS) YES.

Q9)

ANS) YES. The determinant has to be 1, or else it would alter the length of the initial vector which does not happen in series of rotations. Since the individual rotation matrices that are present in the product, are Orthogonal, it would lead to the conclusion that their product is also orthogonal.

BIBLIOGRAPHY:

[1] Yul Shin, S., Deshpande, A. D., and Sulzer, J., 2018, "Design of a Single Degree-of-Freedom, Adaptable Electromechanical Gait Trainer for People With Neurological Injury," Journal of Mechanisms and Robotics, **10**(4), p. 044503.