Part 6 - Angular Kinematics / Angular Impulse

1. While jumping over a hurdle, an athlete’s hip angle was measured to be 2.41 radians. Within 0.15 seconds, the hurdler’s hip angle changed to be 3.29 radians. Consider the athlete’s mass to be 68 Kg, their height is 1.65m, and the thigh segment to be 50cm long. What was the hip angular velocity in degrees/second? What is the average linear velocity of the hip angle? (m^rad/s)

2. In the study of kinematics, joint angle-angle plots can be very useful. What is one important piece of information that an angle-angle plot provides?

3. During cycling, you observe the cyclist’s knee angular velocity to be –80 deg/s. If the final knee angle was 60°, what was the initial knee angle? Assume Δt=1s.

4. Using the moment-time curves below, determine the net angular impulse applied about the somersault axis of a diver from time 1 (0.25s) to time 2 (0.75s). The weight of the diver is 100 N and the height of the TBCM from t1 to t2 is 1 meter above the ground.

5. If the angular velocity at 0.47s was 1.5 rad/s and 2.1 rad/s at 0.51s, what was the average angular acceleration over this time interval?

6. If a skater is rotating during a spin at a constant angular velocity, what is his angular acceleration?

7. Why would a batter in baseball want to “choke up” on a bat when facing a particularly fast pitcher?

8. Calculate the relative knee angle, and absolute segment angles of the shank and thigh given the following joint coordinates. Hip(1.228, 0.931); Knee(1.22, 0.542); Ankle(0.897, 0.160) (Calculate angles in both radians and degrees)

9. A cyclist completes 2.1 cycle revolutions in 1s. What is the a) angular distance in degrees? b) angular displacement in degrees? c) average angular velocity (deg/s)?
10. An individual’s arm segment is 0.15m long and has an angular velocity of 123deg/s. What is the tangential velocity of the wrist in m/s?

Use the graph below to answer the following 4 questions
From the angle-angle diagram of a person running below, answer the following questions. Dots are plotted every 5th frame.

11. What is the hip angle during maximum knee extension?

12. What is the knee angle during maximum hip flexion?

13. What is the interval of maximum knee angular velocity?

14. What is the Range of motion of the hip?

15. During the propulsive phase of a dive (pushing off the diving board), the net vertical and horizontal forces were 200 N and -100 N, respectively. The location of the force under the diver’s feet (x, y) was (0, 0) m and the location of the diver’s center mass was (0.35, 1.1) m. If these forces were applied constantly for an interval of 2 seconds, what was the net angular impulse applied to the body?

16. Identify all the true statements regarding Angle-Angle diagrams
   a) provide information about the coordination between joints
   b) are ideal for cyclical movements such as running and walking
   c) are best suited to provide temporal information about movements
   d) provide information about the range of motion experienced at each joint
17. An individual performed a throw in darts by holding the elbow joint stationary and rotating the forearm-hand (one rigid segment) about the elbow joint. Suppose that the difference from the elbow joint to the dart in the hand was 35 cm and that the forearm-hand had an angular velocity of 15 rad/s at release.

a) What was the linear velocity of the dart at release?

b) What was the distance that the dart traveled horizontally if it landed at the same height that it was released?

18. The graph above is a plot of the knee joint angular position.

a) draw a stick figure of the knee joint as it moves from point a to point b

b) calculate the knee joint angular velocity in rad/s as the knee moves from a to b

c) calculate the knee joint change in position from a to b in degrees

19. A gymnast, during a forward tumbling pass, takes off from the mat in a perfectly vertical position with an angular momentum of 53.6 kgm²/s. The moment of inertia about the center of mass during the entire flight phase was 15 kgm². The flight time was 0.88 seconds. How did the gymnast land?

20. The thigh tends to lag behind during an abnormal gait cycle. If the subject wanted to correct this problem, the thigh would need to rotate 50 degrees through the swing phase, in 0.57 s. The moment of inertia about the center of gravity of the thigh is 2 kgm². What must the angular momentum of thigh be to obtain this amount of rotation?

**Answers**

1. 336.1 deg/s, 2.93 m·rad/s
2. joint coordination
3. 140°
4. 25 Nms
5. 15 rad/s²
6. Zero
7. Thigh angle=88.82°, 1.55rad, Shank angle=49.8°, 0.87rad, knee angle=140.9°, 2.46rad
8. a)756°, 13.2rad b)36°, 0.63rad c) 756°/s
9. 0.32
10. 3.07 Nms
11. 155°
12. 143° or 158°
13. 143° or 158°
14. 65°
15. ~360 Nms
16. a, b, d
17. 5.25 m²·rad/s
18. b)2.5 rad/s c)~14.32°
19. On her head (@-1.57 rad)
20. 3.07 Nms
Bonus Problems
Use the angle-angle diagram below of a sit-to-stand to answer the questions 22-25

1) The ankle-knee angle angle diagram indicates which of the following
   a) The ankle is flexing then extending and the knee is extending
   b) The ankle is extending then flexing and the knee is extending
   c) The ankle is flexing then extending and the knee is flexing
   d) The ankle is extending then flexing and the knee is flexing
   e) None of the above

2) From start to end, what can you conclude about the length of the one-joint quadriceps muscles?
   a) Shortening
   b) Lengthening
   c) Same length
   d) Extending
   e) None of the above

3) What is the best estimate of hip range of motion during the movement?
   a) 1.8 rad
   b) 2.0 rad
   c) 1.6 rad
   d) 0 rad
   e) 3.2 rad

4) What can you conclude about the knee-hip joint coordination pattern from 1 to 3.
   a) As the knee extends, the hip flexes and then extends.
   b) As the knee flexes, the hip extends
   c) As the knee extends, the hip remains constant.
   d) The knee extends as the hip flexes.
   e) None of the above.
5) From movement A to B, the hip extends 80°. If the time to get from A to B was 1.4s, what was the average hip angular velocity in rad/s?

a. 57.1 rad/s  
   b. 112 rad/s  
   c. 1.95 rad/s  
   d. 0.99 rad/s  
   e. 1.4 rad/s

6) Choose the most correct TBCM vertical velocity-time graph below for the movement from A to B.

a  

b  

c  

d