Part 7 - Joint Kinetics

1. What is kinetics?
   a) Incorporates the cause of motion in its application.
   b) The analysis of net joint forces and net joint moments.
   c) Describes the effect of forces.
   d) Includes the consideration of acceleration as a cause of motion.

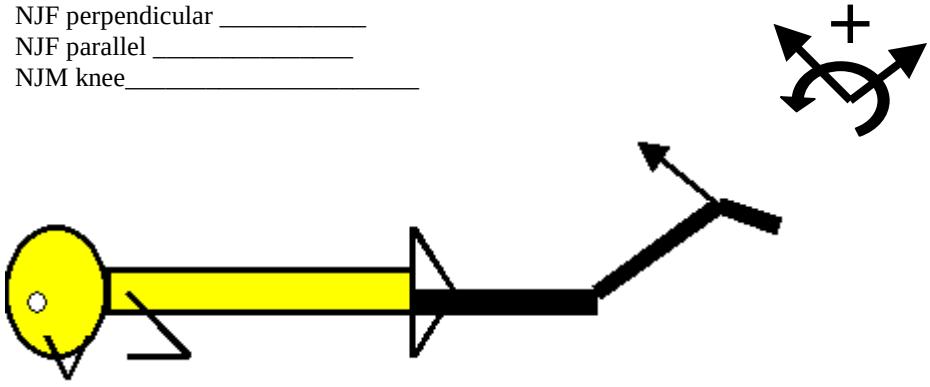
2. A net joint force is
   a) the resistance to rotation
   b) the net linear effect of all forces acting across the joint
   c) the summed rotation effect of all structures crossing a joint
   d) the net mass times the velocity of the system
   e) the linear effect of only muscles crossing a joint

3. When determining the net joint moment at a joint by taking the sum of moments about the segment center of mass
   a) body segment parameters are needed to determine segment weight, center of mass location, and moment of inertia about the segment center of mass
   b) net joint forces need to be known
   c) reaction forces need to be known
   d) angular acceleration must be known and positive
   e) a, b, and c

4. Under static conditions, which of the following statements are true
   a) I_{cm} alpha is zero because the resistance to rotation is zero.
   b) Mass times acceleration is zero because acceleration is zero.
   c) Force is equal to Mass times change in acceleration.
   d) No force is acting on the body.
   e) a, b, and c

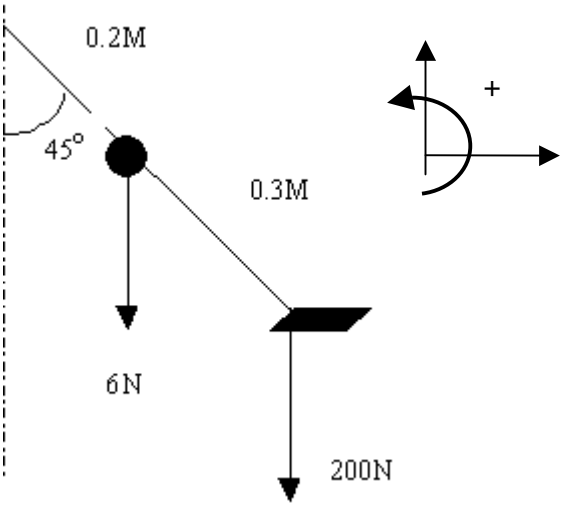
5 The resultant net joint force acting at a joint represents
   a) the minimum force required for the observed motion
   b) the actual compressive and shear forces experienced by the segment at the joint
   c) the rotation effects of all components crossing the joint
   d) the linear effect of forces created only by muscles
   e) all of the above

6. Determine the knee joint kinetics for the following static exercise.
   NJF perpendicular _____
   NJF parallel _____
   NJM knee_____



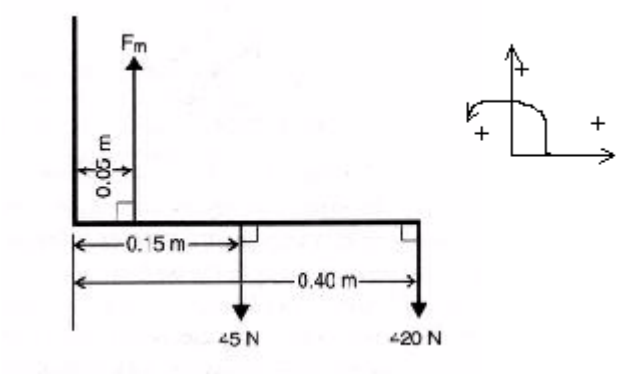
Note:
mass of shank and foot= 20 kg
Location of shank and foot center of mass = 0.1 meters from knee
Force at ankle= 30 N at an angle of 60 counterclockwise relative to long axis of shank
Shank angle relative to thigh= 140 degrees clockwise
shank length = 0.3 meters

7. The picture below shows a 200N weight acting at the ankle. The weight of the shank and foot is 6N, acting at the shank CM. Calculate the NJM at the knee.



8. Use the table and figure below to answer the following question

muscle	**CSA**
biceps brachii	35%
brachialis	53%
brachioradialis	12%



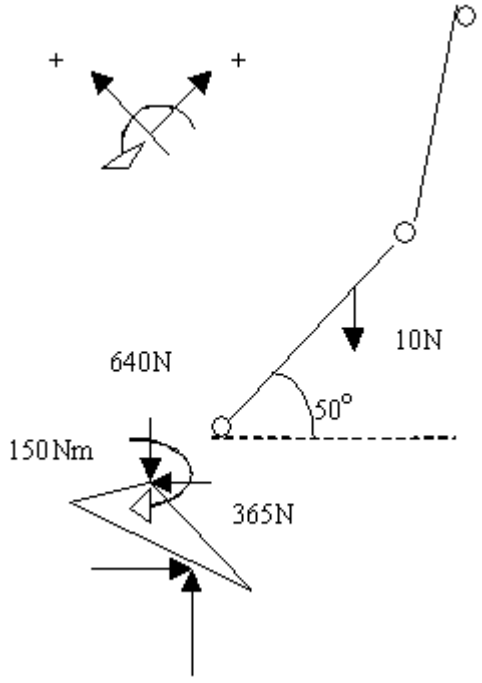
Given above is the FBD of a person performing a static arm curl while holding a 420N dumbell. The weight of the forearm and hand is 45N. Determine the muscle force Fm at this instant. Given the percentage effort of the 3 elbow flexors (in the table above) calculate the individual muscle force of each of the three elbow flexors.

9. All these variables are necessary to determine the net joint moment about the knee except:
   a) Angular acceleration about an axis through the shank center of mass.
   b) mass of the shank segment.
   c) knee angle
   d) shank resistance to rotation about an axis through the shank center of mass
   e) ground reaction forces.

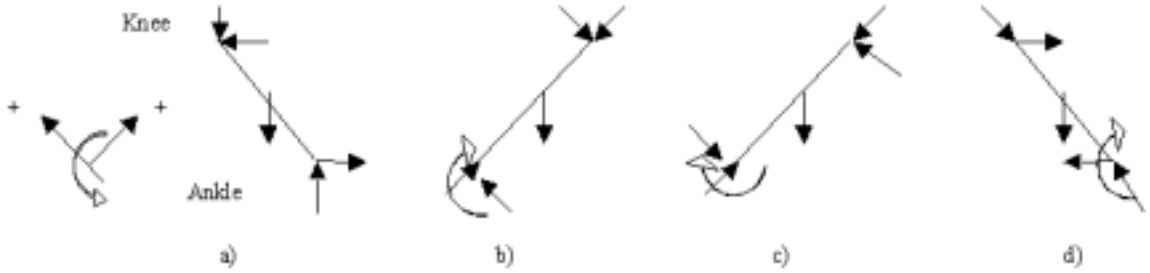
10. Which of the following statements is **false** regarding a segment's moment of inertia
   a. the moment of inertia is dependent on mass distribution
   b. can be determined knowing mass and radius of gyration
   c. the moment of inertia is the segment's resistance to angular acceleration
   d. the moment of inertia is zero under static conditions
   e. the moment of inertia doesn't change while walking

11. Which of the following statement is **false** regarding joint kinetic quantities
   a. the net joint moment represents the net effect of all structures creating a moment about a joint
   b. the net joint force can be separated into perpendicular and parallel components to reflect potential axial and shear loading at a joint
   c. EMG can be used to determine which muscles contribute to the net joint moment
   d. Net joint moments applied to adjacent joints are equal in magnitude but opposite in sign
   e. The magnitude of the net joint moments are **not** influenced by reaction forces applied to the segment

12. From the picture shown, determine the correct equation for solving the $NJF_{\perp}$ at the knee under static conditions.



13. Given that the NJM at the knee is **60Nm**, choose the most correct diagram which would represent this scenario. Assume magnitudes of all NJF's are 10N, segment weight is 5N, and acts 0.5m from either end, and there is a NJM_{ankle}=-50Nm (acting on the shank).



14. A person is statically performing a biceps curl, with a 100N barbell in their hand, 0.35M distal to the elbow, while the forearm is positioned at an angle of 30° relative to the horizontal. The weight of the forearm and hand is 6N, acting at the CM of the forearm, 0.2M distal to the elbow. Determine the equation for calculating the sum of the forces parallel.

15. In the previous example all of the forces producing a moment about the forearm CM are
    a) $100N_{\perp}$, $NJF_{E\perp}$, $NJM_{E\perp}$
    b) $100N_{\perp}$, $6N_{\perp}$, $NJF_{E\perp}$
    c) $100N_{\perp}$, $NJF_{E\perp}$
    d) $NJM_{E\perp}$, $NJF_{E\perp}$, $6N_{\perp}$, $100N_{\perp}$
    e) None of the above

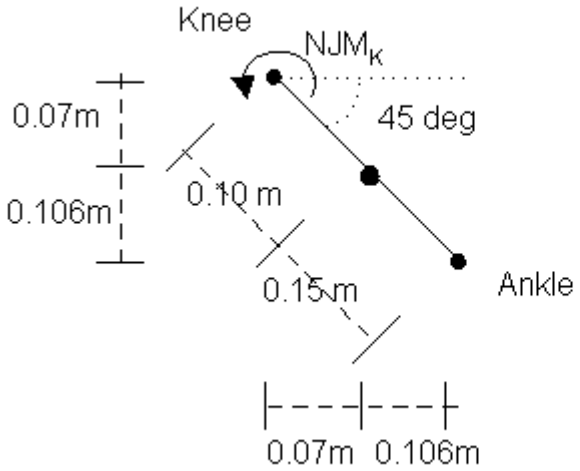
16. Calculate the NJM at the knee with a 125N free weight at the ankle, 0.25M from the shank CM. The weight of the shank and foot is 10N acting at the shank CM. The total length of the shank is 0.45M, and the CM is located a length 44.5% distal to the knee. Assume the leg to be at 180°.

17. A surgeon is considering a radical procedure to improve the moment production of the muscles that cross the knee (uniarticular vasti) for a child with gait difficulties. Under consideration is moving the attachment point either more proximal (closer) or more distal (further) to the knee. As the research assistant you are asked to evaluate the procedure. After considerable research you find that 3 factors will be affected by the surgery: the location of attachment from the knee (point of rotation), the angle of the muscle with respect to the bone, and the muscle length which affects the amount of force the muscle can produce (force-length relationship). Given the following data which option would you recommend and WHY?

Condition	Attachment	Angle	Force at Length
Pre Surgery	3 cm	10 deg	450 N
Proximal Surgery	1 cm	15 deg	400 N
Distal Surgery	5 cm	6 deg	500 N

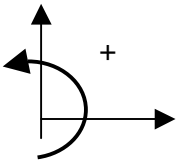
    a) No surgery
    b) Proximal Surgery
    c) Distal Surgery
    d) Either Proximal or Distal Surgery
    e) Need more information to make the determination.

18. You want to help a volleyball player train to jump higher. As part of that analysis you conclude that you want some information about what the knee is doing at a given instant in time. Given the following what is the net effect of the muscle activity at the knee joint?



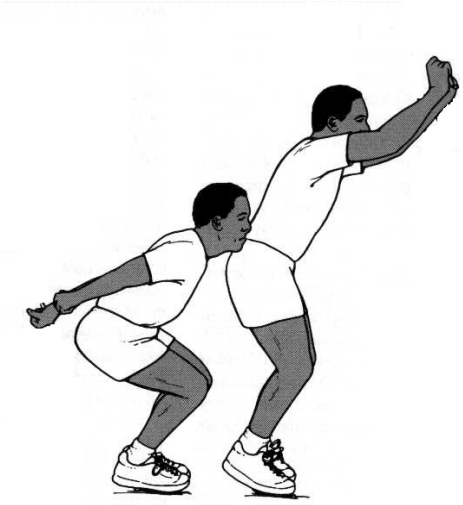
$NJF_{\perp K} = -41.4$ N
$NJF_{//K} = -34.4$ N
mass = 0.51 kg
$NJF_{\perp A} = 50$
$NJF_{//A} = 40$ N
$NJM_A = 400$ Nm
$I_{cm} = 5\ kgm^2$
$a_{//} = 4\ m/s^2$
$a_{\perp} = 10\ m/s^2$
$\alpha = 10\ rad/s^2$

19. In the period of gait from heel strike to foot flat, there are forces acting on the foot and ankle joint. From the force plate we determined the vertical and horizontal ground reaction force as 300 N (vertical) and 50 N (horizontal). The mass of the foot is 1 kg. The distance from the ankle to the center of gravity of the foot is 6 cm (horizontal) and 6 cm (vertical). The distance from the ankle to the ground reaction force vector is 15 cm (horizontal) and 10 cm (vertical).

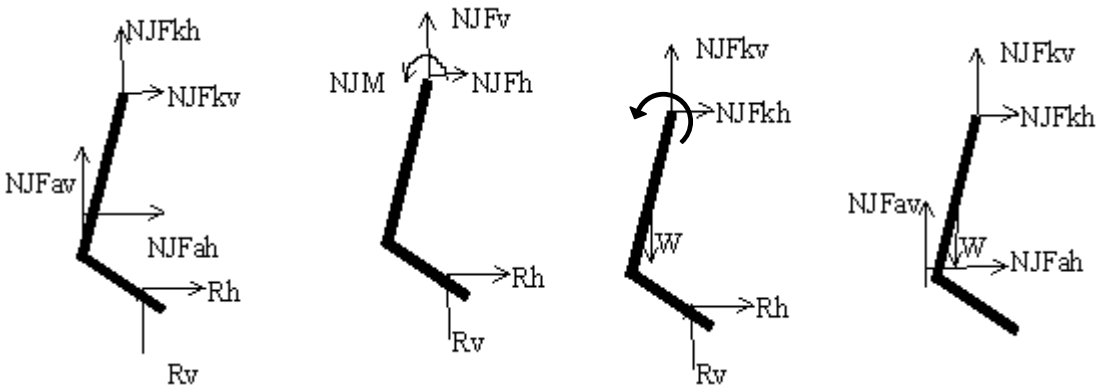


a) Determine the vertical ankle joint force assuming the foot is in a static condition.
b) Determine the NJM at the ankle under static conditions.
c) If this were a dynamic situation, using the NJM calculated above, what would the angular acceleration of the foot CM be given the moment of inertia of the foot = $4.94 Kgm^2$?

20. According to the picture below, identify the correct FBD to use when determining the net joint force at the knee. Assume the foot and shank is a rigid system.

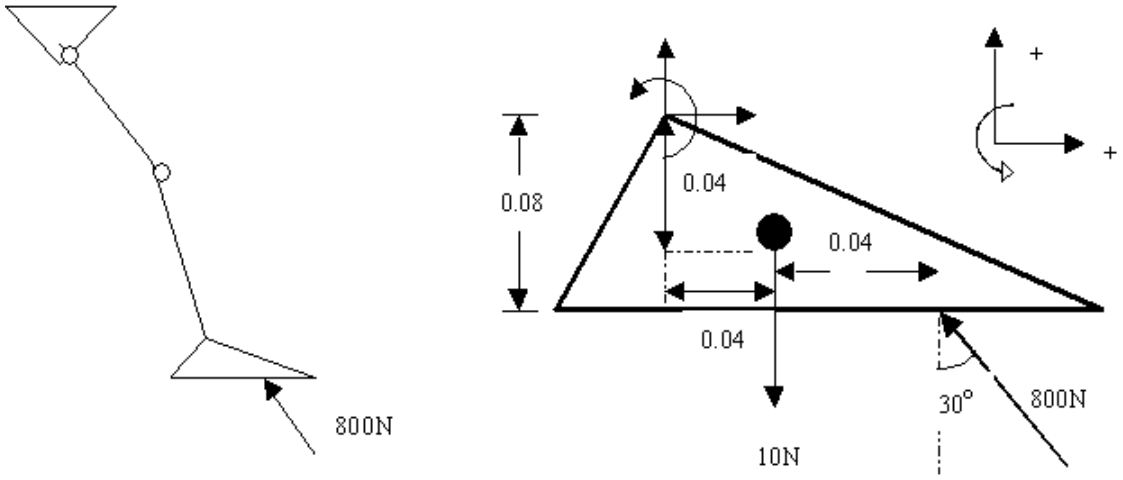


a) b) c) d) e)



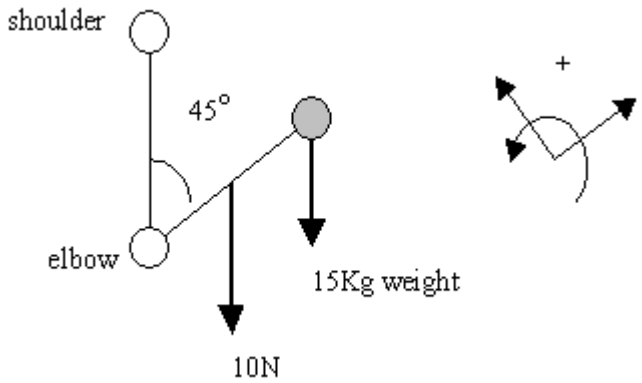
None of the above

21. Given the diagram below, calculate the NJF's and NJM at the ankle. all=a⊥=10m/s2, Icm=0.05, α=100rad/s2

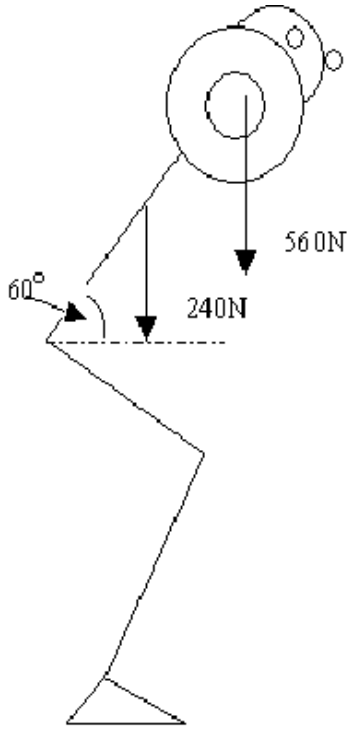


22. Using the information from the previous problem, calculate the NJM at the knee. Consider the shank to be at an angle of 110° relative to the right horizontal positioned at the ankle. The weight of the shank segment is 25N and the length is 0.5m. The CM is 30% of total length taken from the proximal. $a_{ll}=a_{\perp}=10m/s^2$, $I_{cm}=0.07$, $\alpha=80rad/s^2$.

23. An athlete is performing a biceps curl with a barbell. The elbow is flexed 45° clockwise from a vertical passing through the shoulder and upper arm. The weight of the forearm and hand is 10N acting at the forearm CM 0.1m from the elbow. If the total forearm is 0.3m in length and the weight in the hand is 15Kg, calculate the NJF's and NJM at the elbow. Assume the wrist to be a rigid system. $a_{ll}=a_{\perp}=5m/s^2$, $I_{cm}=0.06$, $\alpha=20rad/s^2$



24. The next day, the same athlete is in the gym doing squats. Calculate the NJF's and NJM at L5/S1. The weight of the upper body is acting at the trunk CM, 0.25m from C7. Assume the torso length to be 0.75m from C7 to L5/S1. $a_{ll}=a_{\perp}=5m/s^2$, $I_{cm}=0.8$, $\alpha=10rad/s^2$. Use the same reference frame as previous question.



25. Given the information below, what are the vertical and horizontal net joint forces and the net joint moment at the elbow? If the angle between the upper arm and forearm-wrist segments was decreased to 90 degrees, would the muscles have to exert more or less force? Discuss your answer with detail?

    Given: x, y coordinates of elbow = (0, 0) cm
    x, y coordinates of 100N weight = (37, -15) cm
    x, y coordinates of shoulder = (0, 20) cm
    angle between upper arm and forearm-wrist is 112 degrees
    mass of forearm-hand = 2 kg
    percent distance of forearm-hand center of gravity from proximal end = 35%
    moment arm of Biceps (long head) = 1.9 cm
    moment arm of Biceps (short head) = 2.1 cm
    moment arm of Brachialis = 1.5 cm
    cross-sectional area of Biceps (long head) = 4.65 cm^2
    cross-sectional area of Biceps (short head) = 6.2 cm^2
    cross-sectional area of Brachialis = 3.78 cm^2
    moment of inertia = 5 kgm^2

    Assumption: the capacity of a muscle to produce force is proportional to the percent force exerted by the muscle

26. In a static situation, a person is standing on one foot on a force plate. The resultant ground reaction force is found to be 588N at an angle of 120° relative to right horizontal and 0.04m anterior to the foot center of mass. The weight of the foot is 0.9Kg and acts at the CM, 0.06m anterior to the ankle joint. The ankle and center of

pressure are located 0.02m above and below the foot CM, respectively. Calculate the joint reaction forces and NJM at the ankle.

27. A person weighing 70Kg performs a simple heel raise. The weight of the body is assumed to pass through the heads of the metatarsals of the standing foot, 0.15m anterior to the ankle joint. The force through the Achilles tendon acts 0.05m posterior to the ankle joint. How large a force is transmitted through the Achilles tendon when the patient lifts the heel from the floor in order to maintain a static position? Disregard the weight of the foot.

28. When the same person raises up to their toes, the moment arm for the ground reaction force changes to be 0.1m, and the moment arm of the Achilles tendon force is 0.045m. How large a force is transmitted through the Achilles tendon when the patient stands on their toes?

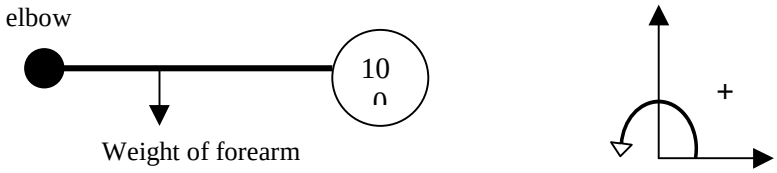
29. A person doing triceps extension is lying on his back and holding a 5Kg dumbbell in one hand, 0.3m from the elbow joint. The shoulder is flexed 90° (the upper arm is 90° to the bench). How large is the moment on the elbow joint produced by the weight of the dumbbell at 120°, 90°, 30°, 0° of elbow flexion? Hint: Draw a FBD for each position. Assume static conditions at each position.

Answers

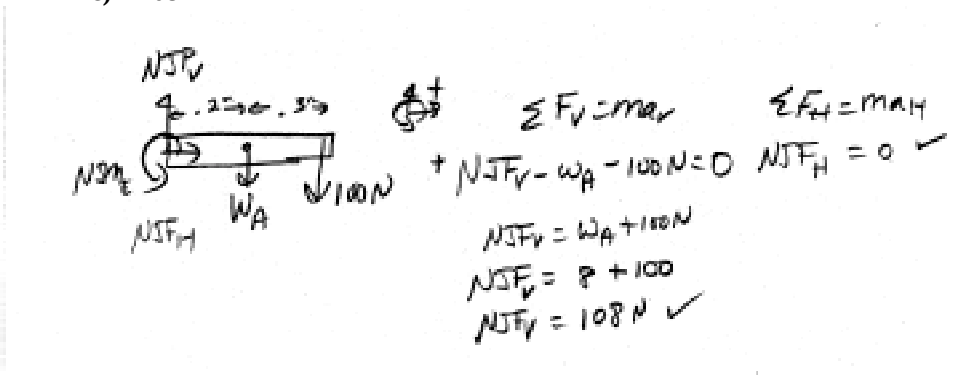
1. a
2. b
3. e
4. b
5. b
6. $NJF_{\perp}$ = 124.3N, $NJF_{||}$ =111.1N, Knee NJM = 7.23Nm
7. 71.54Nm
8. 3495N
9. c
10. d
11. e
12. $NJF_{\perp}$ - (sin50)*365 + (sin40)*640 – (sin40)*10 = 0 , or $NJF_{\perp}$ - 365(cos40) + 640(cos5)0 – 10(cos50) = 0
13. b
14. $NJF_{||}$ - 6N(cos60) – 100N(cos60) = 0
15. C
16. 58.25Nm
17. c
18. –361.14Nm
19. a) NJF_v = -290.19N, NJF_h = -50N; b)NJM = -49.4Nm; c)α = -10 rad/s^2
20. c
21. NJF_h = 410.2N , NJF_v = -672.6N , NJM = -17.2 Nm
22. Knee: NJF_v = 722.6N , NJF_h = -385.2N , NJM = -45.55 Nm
23. $NJF_{\perp}$ = $NJF_{||}$ =116.3N, NJM = 33.65Nm
24. $NJF_{\perp}$ = 522.3N , $NJF_{||}$ =814.1N, NJM = 339.15Nm
25. $NJF_{\perp}$ = 110.9N , $NJF_{||}$ =44.8N, NJM = 39.5Nm
26. NJFh = 294N , NJFv = -500.4N , NJM = -38.63Nm
27. 2,060N
28. 1,526N
29. 12.75N, 14.72N, 7.36N, 0N

Bonus Problems

1) Determine the net joint force at the elbow needed to hold the 100 N hand weight in static position. Assume the forearm is horizontal, weighs 8N and segment center of mass is located 0.2 meters from elbow and 0.3 from the hand weight.

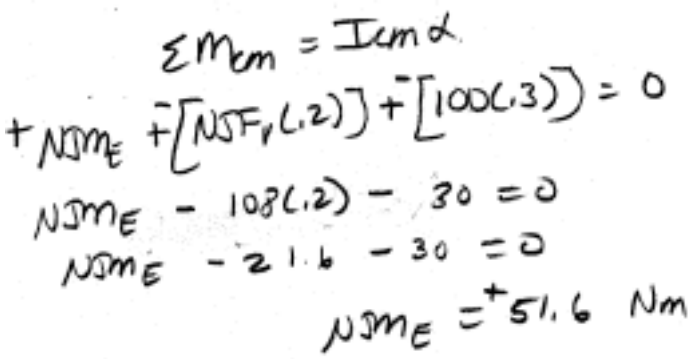


a) 8 N
b) 78.48 N
c) 92 N
d) 100 N
e) 108 N



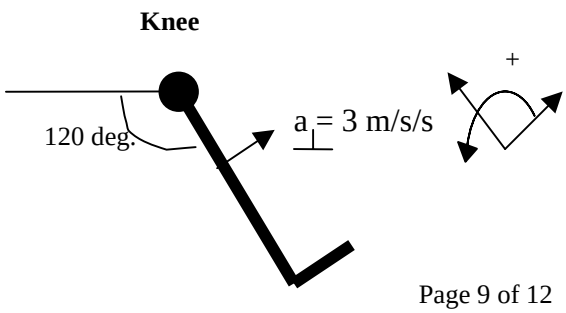
2) Use the above information to determine the net joint moment at the elbow.

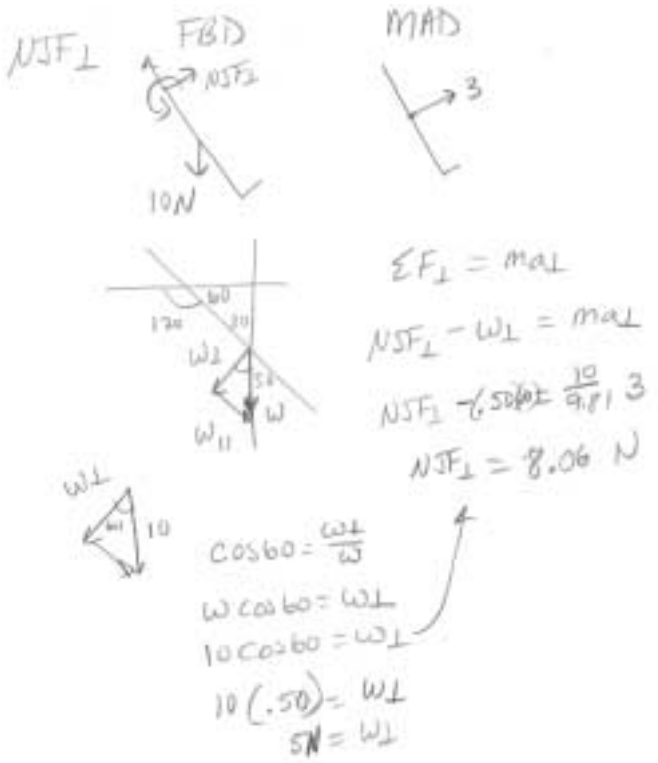
a) 21.6 Nm
b) 30 Nm
c) 51.6 Nm
d) 71.6 Nm
e) 101.6 Nm



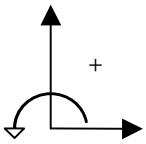
3) Determine the perpendicular component of the net joint force at the knee needed to accelerate the foot and shank segment center of mass +3 m/s/s in a direction perpendicular to the long axis of the segment. Assume the weight of the foot and shank system is 10 N. and knee angle of 120 degrees.

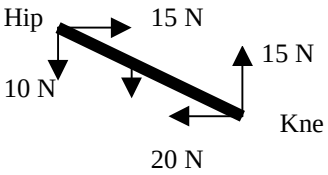
a) 5 N
b) 8.06 N
c) 11.76 N
d) 3.56 N
e) 38.06 M

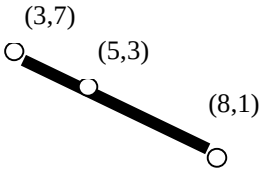




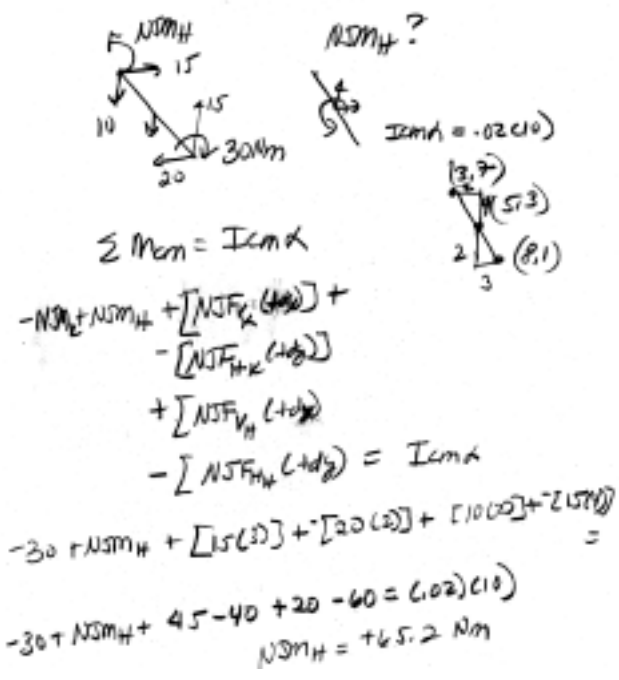
4) If the knee net joint moment is – 30 Nm, determine the net joint moment needed at the hip needed to create an angular acceleration of 10 rad/s/s of the thigh about the segment center of mass. Assume a moment of inertia of the thigh of 0.02 and net joint forces as drawn on the picture below. Remember to start with a complete FBD.

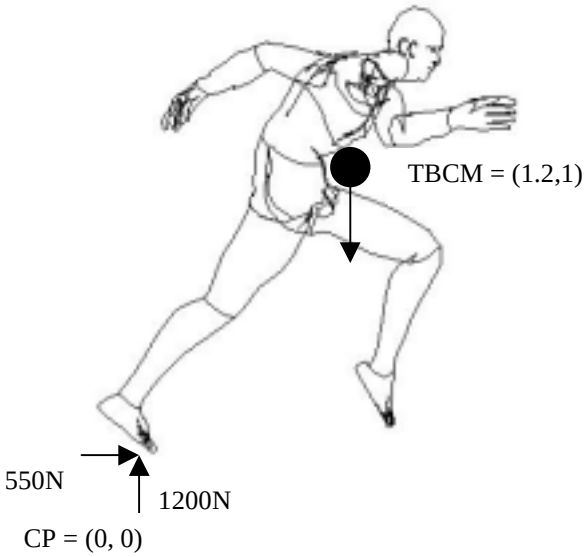




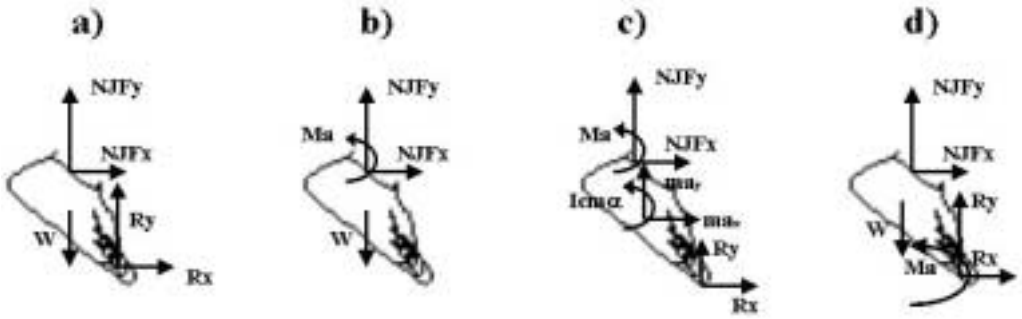


a) 195.2 Nm
b) 50.2 Nm
c) 75 Nm
d) 35.2 Nm
e) 65.2 Nm

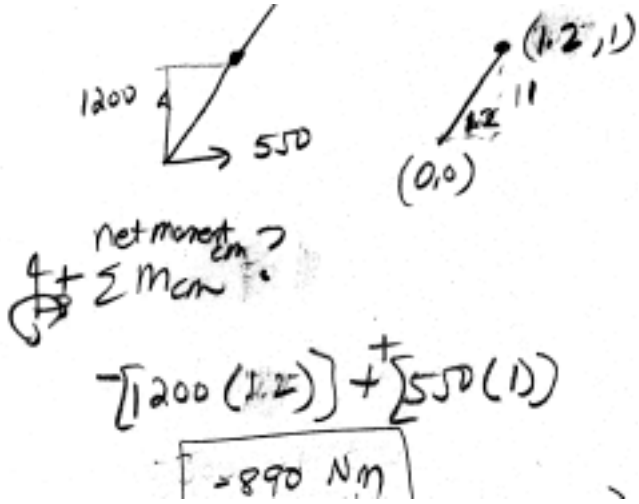




5) Identify the correct free-body-diagram of the foot on the swing leg of the sprinter. The sprinter weighs 600 N.
ANS: B



6) Calculate the net moment about the TBCM of the sprinter created by the ground reaction forces acting at the center of pressure. The sprinter weighs 600 N.
   a. -1990 Nm
   b. –1440 Nm
   c. –540 Nm
   d. - 890 Nm
   e. –170 Nm



7) Which of the following statements provides the best definition of a net joint force?
   a) The net demand placed on the joint capsule and soft tissue.
   b) The net linear effect of all structures crossing the joint.
   c) The net linear effect of the extensor muscles crossing the joint.
   d) The net rotation effect of the muscle producing force.
   e) The net rotation effect of the muscle to resist joint flexion.

8) Which of the following statements provide the best definition of a net joint moment.
   a) The net rotation effect of the joint extensor muscles.
   b) The net rotation effect of all structures crossing the joint.
   c) The rotational effect of muscle crossing the joint.
   d) The net demand placed on the joint capsule and soft tissue.
   e) The net rotation effect of the muscle to resist joint extension.

9) Which of the following statements provide the best definition of moment of inertia.
   a) Resistance to rotation about the TBCM.
   b) Distribution of mass about the joint.
   c) Resistance to translation about the TBCM
   d) a and b
   e) Resistance to movement in all direction

10) Determine the muscle force needed to create a moment about the shoulder of 30 Nm. Assume the perpendicular distance from the joint axis to the line of muscle force is 0.025 m.
   a) 120 N
   b) 600 N
   c) 720 N
   d) 1200 N
   e) 1800 N