ENS 306
Biomechanics of Human Motion
Spring 2004
COM Calculation

Items you will need:	**Items provided:**
Calculator	Tables
Pencil	Silhouette
Ruler (metric)	Calculation tables

Steps in calculating the CoM of a figure:

Step 1: Creating points

Identify and estimate the following key bony landmarks:

- ?? Crown of the head
- ?? 7th cervical vertebrae (C7)
- ?? Right shoulder (GH joint)
- ?? Right elbow
- ?? Right wrist
- ?? 3rd digit on right hand
- ?? Left shoulder (GH joint)
- ?? Left elbow
- ?? Left wrist
- ?? 3rd digit on left hand
- ?? Right greater trochanter
- ?? Right knee
- ?? Right ankle
- ?? 3rd digit on the right foot
- ?? left greater trochanter
- ?? left knee
- ?? left ankle
- ?? 3rd digit on the left foot

The silhouette is a 2-D representation of a movement. It will require that you estimate the location of the listed landmarks and joints. In some cases the nature of the movement may indicate that the landmark is obscured due to the limitation of 2-D viewing. For instance, when running the torso will be rotated and may obscure the view of the adjacent shoulder. Based on your knowledge of the activity, you will need to estimate the location of the shoulder joint and then complete the segment. All estimations should be made at the center of the joint and not at the surface of the skin.

Example: knee joint center

Correct Incorrect

Step 2: Connect the segments

Connect the dots that you created for each joint to form the following segments:

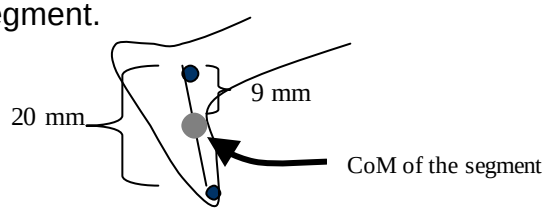
?? head
?? trunk
?? Right upper arm
?? Right forearm
?? Right hand
?? Left upper arm
?? Left forearm
?? Left hand
?? Right thigh
?? Right shank/calf
?? Right foot
?? Left thigh
?? Left shank/calf
?? Left foot

Step 3: Measure the segment
Measure the length of the segments and record in Chart A in the L(mm) column. Be sure to measure in millimeters.

Step 4: Location of COM
Use **Table 5.5** *Segmental Center of Mass Locations with Respect to the Upper Boundary of the Segment* and fill in the location percentages for each segment. Use the **Clauser (1969) data** in the last column due to the sample size from which the values were derived. Place the value in the *% location of COM* section of Chart A.

Step 5: Determining the CoM for each segment
Multiply the two values in Chart C and place the answer in the *product* column. Place your ruler on the segment connecting the two points. Take the *product* value and measure its length (in mm) from the proximal point of the segment along the segment and place a mark. This new point represents the CoM of the segment. Repeat for each segment.

Example: L(mm) = 20 mm
% location = .45
product = 9 mm



Step 6: Develop (x,y) coordinates for each segment
Take the ruler and draw right angles to the point in the x and y direction. Each line should be drawn to the x & y axis, respectively. Measure the distance from the origin in each direction and label the CoM point with the appropriate (x,y) convention. Do this for each CoM point for all segments.

The values, or orientations (O), can be recorded in Chart B for the horizontal (Ox) and vertical (Oy) components. By converting the values from Step 5 into coordinates, you are able to determine the relative mass and location of the CoM in respect to the given movement.

Step 7: Segmental weight ratios
Transfer all of the values form Chart B into the appropriate location in Chart C. Next, use **Table 5.4** – *Segmental Weight/Body Weight Ratios from Several Cadaver Studies* to fill in the in the ratio for each of your label segments in the column labeled *Segmental Wt. Ratio*. Again, the value in the table represents a percentage of total body weight (Sum equals 100%). We intend to multiply these values with our Ox & Oy, so we need to convert the percentage from the table into a ratio (ie: 50% = .50; or, 7.3% = .073). If you neglect to convert the values, your answers will not make reasonable sense. Do this for each segment.

Step 8: Moments
A moment is a value that represents the amount of rotation that may be occurring at a particular point. Calculating the moments in the x & y direction will tell us where rotation, or motion, is occurring in a segment. This is an important concept to understand if you wish to improve or enhance motion.

To calculate a moment (M) you will need to take the *Segmental Wt. Ratio* and multiply it with the Ox and Oy, respectively. The products of each response should be placed in the M(Ox) and M(Oy) columns in Chart C.

Step 9: Sum of Moments
The interesting concepts in this process is that the CoM of the body can be calculated by adding or summing, the moments of each segment. When you consider this concept, it makes sense. When the locations of each segment are resolved with one another, the outcome should present a **single point** that represents the dispersal of weight during any given movement.

Take all of the values in the M(Ox) column and add them together. The answer should be recorded on the line labeled *Sum of Moments* in Chart C. Do the same for M(Oy) and record. These values represent the coordinates (x,y) for the CoM of the figure.

Step 10: Last step!
Take the coordinates you just calculated and plot them on the figure using your ruler. Label the point as the CoM and place the (x,y) next to it.

Try to make sense of the point you created. How does this point relate to our CoM in standing posture or anatomical position? Where is your point located in respect to that "static" position? Why does this make sense, given the movement in the silhouette?