Biomechanics
Quiz 1

name_____

Show all work and **all logic**. If needed feel free to ask for clarification. Enjoy!

1
2
3
G

Given: 1 psi = 6.895 kPa, 1 lb = 4.48 N, 1 inch = 25.4 mm. g = 9.81 m/sec^2 = 32.2 ft/sec^2. 60 mph = 88 ft/sec. 1 m = 3.281 ft. 1 m/sec = 2.237 mi/hr. E = 2G(1 +ν) . **F** = m**a**. **M** = I**α**

$\sigma = My/I$; $1/\rho = M/EI$. $I = \frac{1}{12}\, bh^3$. $I = \frac{\pi}{4}\, r^4$. $I = \frac{\pi}{4}(r_o^4 - r_i^4)$. $\sigma = \frac{P}{A}$. P = F v. 1 hp = 746 W.

$\varepsilon_{xx} = \frac{1}{E}\{\sigma_{xx} - \nu\sigma_{yy} - \nu\sigma_{zz}\}$. $v_f^2 - v_i^2 = 2ay$. P = dW/dt. $v_s = \sqrt{G/\rho}$. $v_L = \sqrt{C_{1111}/\rho}$.

Given: $C_{1111} = E\frac{1-\nu}{(1+\nu)(1-2\nu)}$

Question 1
P: to center line
R: Wrist bones
S: Force per area upon an oriented plane.
T: Displacement per length
U: ankle bones
V: kneecap
W: joint between skull bones
X: knee joint
Y: shoulder joint

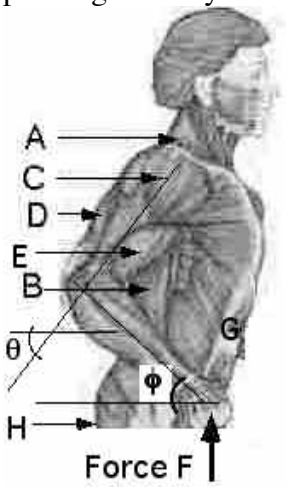
1. (30 pts) Refer to the diagrams and to the right. Place the appropriate **letter** in each box. Some letters may be left over. Letters are to the right and in diagrams.

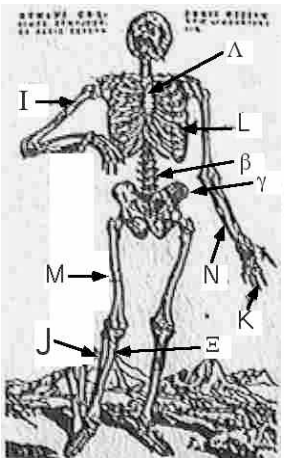
(a) femur ☐	(f) ulna ☐	(k) stress ☐
(b) fibula ☐	(g) triceps ☐	(l) strain ☐
(c) patella ☐	(h) clavicle ☐	(m) carpals ☐
(d) ribs ☐	(i) gluteus maximus ☐	(n) tarsals ☐
(e) humerus ☐	(j) trapezius ☐	(o) scapula ☐

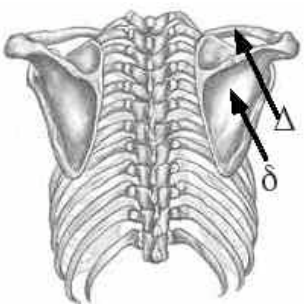
2. (40 pts) **Consider an athlete of mass 75 kg running up the stairs.** Each floor consists of 22 steps of height 17 cm. The runner goes up five floors in 28 seconds.
(a, 12 pts) How fast, in mph, is the runner going in the vertical direction?
(b, 12 pts) How much mechanical power in horsepower is generated in raising the body?
(c, 16 pts) Determine the relationship between vertical speed v and athlete height L, assuming body composition and proportions do not depend on athlete height, and available power is proportional to lung area.

3. (30 pts) **Consider a slow arm extension**, shown in the left diagram. The body weight is W and height is L. Consider the **triceps**. It connects to the infraglenoid tuberosity of the scapula and to the humerus. The tendon of the triceps connects to the olecranon. The olecranon is a large, thick, curved eminence, situated at the upper and back part of the ulna.

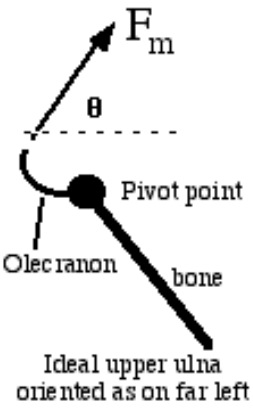
Assume the triceps is attached a distance **a** parallel to the ulna from the pivot point of the elbow joint. Assume the force exerted by the triceps on the olecranon is directed along the humerus. The forearm has length **b** from the elbow pivot point to the grip center of the hand. The hand presses down and receives a reaction force **F** at the grip center as shown. Angle θ from humerus to horizontal and ϕ from ulna to horizontal are known.
(a) Draw a free body diagram of the forearm from the elbow to the hand. Assume only the triceps is tensed.
(b) Determine the triceps muscle force $\mathbf{F_m}$ in terms of force **F**. Letters A to E; G, H do *not* refer to forces.
(c) The athlete grips horizontal bars, one on each side of his body, and raises his body to leave the floor by pressing down symmetrically with both hands on the bars. What is the minimum value of the force **F**?








Actual upper ulna



Ideal upper ulna oriented as on far left