AS-74.3136 Introduction to Microsystems

Examination 11.05.2009
Quan Zhou

No Books are allowed in the exam!

1. a) What are microsystems? (2 point)
   b) What is the difference between Microsystems and microelectronics? (2 point)

2. a) What are the main steps of LIGA Technology? (2 point)
   b) What are the similarities and differences with silicon microfabrication? (2 point)

3. Draw a diagram and describe the working principle of atomic force microscopy (AFM). (2 point)

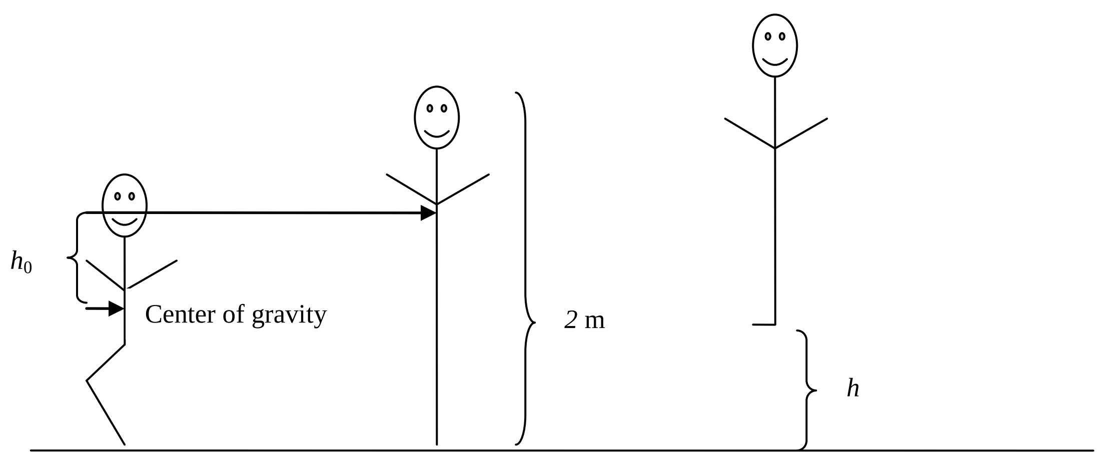
4. Draw and explain the working principles of the piezo resistive and the capacitive pressure sensors. (3 point)

5. How is the adhesion problem solved between a tool and micro part under manipulation? (3 point)

6. Give three examples of microsystem technology in bio applications. (3 point)

7. Explain the working principle of an electrostatic actuator. (3 point)

8. a) Describe the concept of scaling effect? (2 point)



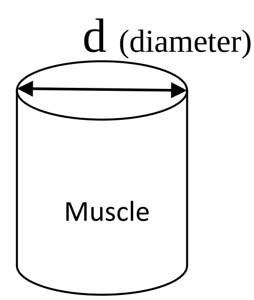
b) We assume a person Antti of 2 meters tall, 80kg in weight, and be able to jump as high as h = 1 meter (he can elevate his center of gravity for 1 meter, possibly equivalent to 2 meters high jump, where the record is 2.45 meters by Javier Sotomayor from Cuba). We also assume that the jumping process is a constant acceleration motion, and the total extension of the body before takeoff h_0 is 1m.

The question is how high a proportionally scaled Antti (in all dimensions) can jump if the scale is 10 times greater (linearly, be the Great Antti) and 10 times smaller (linearly, be the Mini Antti). (6 point)

To make the problem simple, we provide basic physics and some hints for your assistance:

1. The jump height is related to the take off velocity.
   $h = \frac{V^2}{2g}$ from the conservation of energy, where V is the take off velocity, g is the gravitational constant (you can use g = 10 m/s^2 in your calculation).

2. The effective force that enables the jump can be calculated by $F = F_{jump} - mg$, where F_{jump} is the force created from the muscle for jumping, which is assumed to be constant during the whole jumping process before takeoff, and m is the weight or mass of the person. Be aware that F_{jump} is proportional to the cross-section of the muscle:
   $$\sigma = \frac{F_{jump}}{A}$$
   where σ (stress) is constant for every muscle, and A is the nominal area of the muscle for jumping of the person.



3. Due to the effective jumping force is assumed constant, the jumping process before takeoff is a constant acceleration motion. Therefore, the takeoff velocity V can be calculated using:
   $$V = at_0 = \frac{F}{m}t_0$$
   where t_0 is the jumping duration before takeoff, which can be estimated from:
   $$h_0 = \frac{1}{2}at_0^2 = \frac{1}{2}\frac{F}{m}t_0^2$$
   where h_0 is the extension of the maximum extension of the body between starting and ending of the jumping before takeoff.
4. It is better to estimate the F_{jump} for the normal Antti first, before calculating the scaled version.