INFOMGP - GAME PHYSICS

EXERCISES LECTURE 8

EXERCISE 8.1

Imagine a game character weighting $80\ kg$ standing straight on a flat ground. His feet are both represented by 15cmx5cmx3cm boxes (3 cm is the height).
What is the stress produced by a foot on the floor over the contact surface?

First we need to calculate the force applied on the ground. We only consider the gravity here, so $F = mg = 80 \times 9.81 = 784.8$ N
As the character stands straight up, we can consider that the force is evenly distributed over the two feet. So the force is divided by two *i.e.* $F = 392.4$ N
The surface of stress is the surface of contact of the foot on the ground, i.e. $A = 0.15 \times 0.05 = 7.5 \times 10^{-3}$ m^2.
The stress is the average force per unit area, so $\sigma = \frac{F}{A} = 392.4/7.5 \times 10^{-3} = 52320$ Pa

EXERCISE 8.2

Muscles can stretch and compress along a preferred direction, the fiber. Imagine a game character doing pushups. At rest the medial axis of his biceps is 25 cm long and during maximal contraction is 17 cm long.
What is the strain of the muscle during maximal contraction?

The strain is defined as the ratio of deformation to the initial dimension, so

$$\epsilon = \frac{\Delta L}{L} = \frac{17 - 25}{25} = -0.32$$

EXERCISE 8.3

If the internal force occurring in the muscle of exercise 8.2 during the pushups is -100 N and the average cross section area of the biceps is 4 cm^2, what is the Young's modulus of the muscle?

The Young's modulus is defined as the linear stress divided by the linear strain.

$$Y = \frac{\sigma}{\epsilon} = \frac{F/A}{\Delta L/L} = \frac{(-100/0.0004)}{-0.32} = 781250\ Pa \approx 0.8\ MPa$$

EXERCISE 8.4

Imagine a game character is celebrating his birthday and is blowing candles on a jello cake. The force of the blow is directed towards the top surface of the cake and is of magnitude 0.1 N. The cake is a cylinder of radius 8 cm and height 10 cm. During the blow, the top of the cake has moved 2 cm in the direction of the force, and the candles have been extinguished!
What is the shear modulus of the jello cake?

The shear modulus is the ratio of planar stress to planar strain $S = \frac{F/A}{\Delta L/L}$.
Here is the planar stress is calculated as $\sigma = \frac{F}{A} = \frac{F}{\pi r^2} = \frac{0.1}{\pi 0.08^2} = 4.97$ Pa
The planar strain is calculated as $\epsilon = \frac{\Delta L}{L} = \frac{0.02}{0.1} = 0.2$
The shear modulus is then $S = \frac{4.97}{0.2} = 24.87$ Pa

EXERCISE 8.5

A game character needs to operate a water gun. For that, an air compartment is designed in the cylindrical barrel of the gun of radius 2 cm and length 10 cm. The character has to compress the air before release (the air will push the water out of the gun). The Bulk modulus of air is 10^5 Pa.
What force is needed to compress the air within half of the barrel?

We have the relation between Bulk modulus, stress and strain $\Delta P = B \times \frac{\Delta V}{V}$
The pressure at rest is zero (no force) and the surface of pressure does not change, so $\frac{F}{A} = B \times \frac{\Delta V}{V}$
Then,
$F = A \times B \times \frac{\Delta V}{V} = \pi \times 0.02^2 \times 10^5 \times \frac{\pi \times 0.02^2 \times (0.1 - 0.05)}{\pi \times 0.02^2 \times 0.1} = 62.8$ N