AP PHYSICS 2
SUMMER PREVIEW

Name: ____

- Your summer homework assignment is to read through this summer preview, making any annotations you feel necessary, and completing TASK 1.

- It is important that you read through the notes before attempting to solve the problems in TASK 1.

- Task 1 is due the first day of class and will be counted as your first homework grade.

- You can expect a quiz during the first few days of school that is based solely upon the material contained in this summer preview.

- All of the work and calculations necessary to solve the problems in Tasks 1 must be shown to receive credit for this assignment.

- This is an individual assignment. As such, you may not copy any part of the solutions to this assignment from another student nor may you allow any other student to copy any of your work.

ELASTICITY; STRESS AND STRAIN

In Physics 1 we studied how to calculate the forces on objects in equilibrium. Now we will study the effects of these forces; any object changes shape under the action of applied forces. If the forces are great enough, the object will break, or fracture.

ELASTICITY AND HOOKE'S LAW

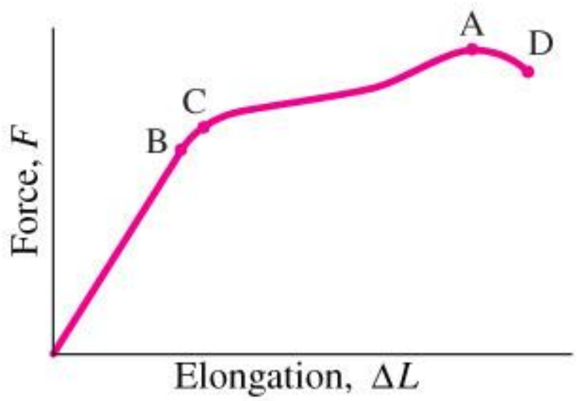
If a force is applied to an object, such as a vertically suspended metal rod, the length of the object changes. If the amount of the elongation ΔL is small compared to the length of the object, then the elongation ΔL is proportional to the force exerted on the object. This proportionality can be written as:

$$F = k\Delta L$$

This relationship was studied in Physics 1 and referred to as Hooke's Law. This relationship is valid for almost any solid material, but only up to a certain point. If the force is too great, the object stretches excessively and eventually breaks.

The figure below shows a typical graph of applied force versus elongation. Up to a point called the proportionality limit (point B on the graph), Hooke's Law is valid, and the curve is a straight line. Beyond this point the graph deviates from a straight line. Up to a point farther along the curve called the elastic limit (point C) the material would return to its original shape if the force was removed. The region from the origin to the elastic limit (A to C) is called the elastic region.

If the object is stretched beyond the elastic limit it enters the plastic region; it does not return to its original shape when the force is removed. The maximum elongation is reached at the breaking point (D). The maximum force that can be applied is called the ultimate strength of the material.



Point A is the ultimate strength of the material
Point B is the proportionality limit
Point C is the elastic limit
Point D is the breaking point

YOUNG'S MODULUS

The amount of elongation of an object depends not only on the force applied to it, but also on the material of which it is made and its dimensions. If we compare rods made of the same material but of different length and cross-sectional area, it is found that for the same applied force, the amount of stretch is proportional to the original length and inversely proportional to the cross sectional area.

$$\Delta L \sim \frac{F}{A} L$$

This proportionality can be re-written:

$$E = \frac{F/A}{\Delta L/L}$$

Where E is known as Young's Modulus; its value depends only upon the material. The value of Young's Modulus for various materials is given in the following table.

Young's Modulus, Bulk Modulus, and Shear Modulus of Various Materials

Material	Young's Modulus (10^9 N/m^2)	Bulk Modulus (10^9 N/m^2)	Shear Modulus (10^9 N/m^2)
aluminum	70	70	25
brass	100	80	40
concrete	30	13	15
iron	190	70	65
nylon	3	—	4.1
rubber band	0.005	—	0.003
steel	200	140	78
air	—	1.01×10^5 N/m^2	—
ethyl alcohol	—	1.0	—
water	—	2.0	—
human ACL	0.1	—	—
human lung	—	$1.5–9.8 \times 10^3$ N/m^2	—
pig endothelial cell	—	—	2×10^4 N/m^2

Example:
A 1.60 m long steel piano wire has a diameter of 0.20 cm. Determine the tension in the wire if it is stretched 0.25 cm when tightened. (980 N)

STRESS AND STRAIN

Force per unit of cross-sectional area is expressed as stress:

$$\sigma = F/A$$

Strain is defined as the ratio of the change in length to the original length:

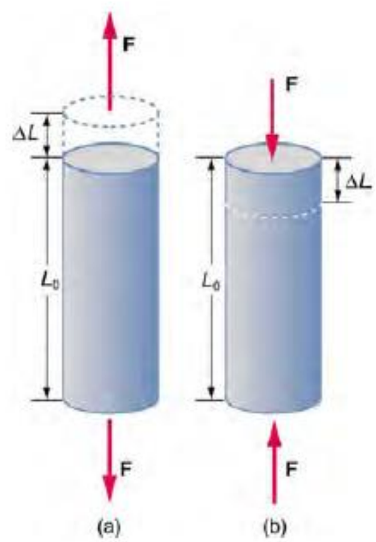
$$\epsilon = \Delta L/L$$

Young's Modulus can be defined as stress divided by strain:

$$E = \frac{\sigma}{\epsilon}$$

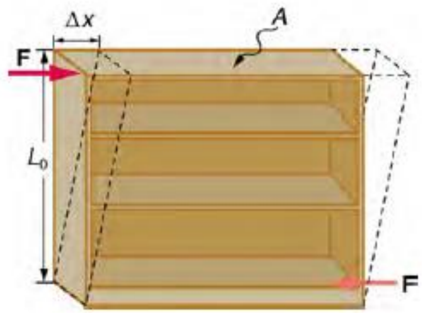
TENSION, COMPRESSION AND SHEAR STRESS

The rod shown on the left in the figure below is under tension or tensile stress. The tensile strength exists throughout the material because every part of the material is in equilibrium. This implies that external forces create internal forces, or stress, inside the material.



Compressive stress is the opposite of tensile stress. Instead of being stretched, the material is being compressed. The rod shown to the right in the figure above is experiencing compressive stress. Columns that support great weight are examples of members being subject to great stresses. The same mathematical relationship is valid for both tensile stresses and compressive stresses.

An object undergoing shear stress has equal and opposite forces applied across its opposite faces.



A relationship similar to tensile and compressive stresses exists, but it involves Shear Modulus G instead of Young's Modulus E. Values for the shear modulus were given in the same table as Young' Modulus.

$$G = \frac{F/A}{\Delta x/L_0}$$

TASK 1 – Don’t Stress Out Name: __________

1. Is Young’s Modulus for a bungee cord larger or smaller than for that of an ordinary rope?

2. Examine how a pair of scissors or shears cuts through a piece of cardboard. Is the name “shear” justified? Explain.

3. A nylon string on a tennis racket is under a tension of 275 N. If its diameter is 1.00 mm, by how much is it lengthened from its unstretched length of 30.0 cm?

4. A marble column of cross-sectional area 1.2 m^2 supports a mass of 25,000 kg.
   (a) What is the stress within the column?
   (b) What is the strain?
   (c) By how much is the column shortened is it is 9.6 m high?

5. A sign of mass 2100 kg hangs from a vertical steel girder with cross-sectional area 0.15 m^2.
   (a) What is the stress within the girder?
   (b) What is the strain on the girder?
   (c) If the girder is 9.50 long, now much is it lengthened?

6. A 15 cm long tendon was found to stretch 3.7 mm by a force of 13.4 N. the tendon was approximately round with an average diameter of 8.5 mm. Calculate the Young's Modulus of this tendon.

7. Engineers are often used to determine the probable cause of a catastrophe such as a bridge collapse or a plane crash. Material failure can be traced back to an overabundance of either tensile, compressive, or shearing stress. The failure produced by each stress creates unique and permanent change in the shape of the material prior to its failure. Using what you have learned about stresses, determine what the permanent deformation would look like it is were over stressed by tension, compression, and shearing. Fill in the table below first with your prediction, and then with what you found by conducting s simple search on the internet. Please cite the source of your information.

Stress	Prediction	Research	Source
Tension			
Compression			
Shear			