Physics 02-04 Tension, Hooke's Law, Drag, and Equilibrium Name: _____

Hooke's Law

For _____ or forces that _____ (change shape)
For _____ deformations (no permanent change)

$$F_S = k\Delta x$$

k = _____ and is unique to each spring
Δx = the _____ the spring is stretched/compressed
Hooke's Law is the reason we can use a _____ scale to measure _____

Tension

_____ force from rope, chain, etc.
_____ the rope connects to something, there is an _____ tension

Drag

_____ force from moving through a _____
Size depends on area, speed, and properties of the fluid
For _____ objects

$$F_D = \frac{1}{2}C\rho A v^2$$

Where
C = _____ coefficient
ρ = _____ of the fluid
A = _____ area of the object
v = _____ of the object relative to the fluid

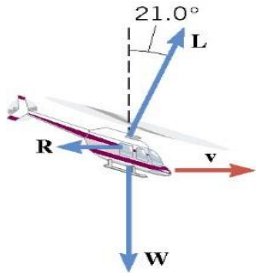
Equilibrium

No _____

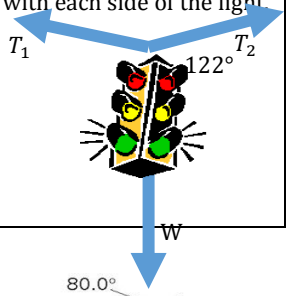
$$F_{net} = ma \rightarrow F_{net} = 0$$

Find the terminal velocity of a falling mouse in air (A=0.004 m^2, m=0.02 kg, C=0.5) and a human falling flat in air (A=0.7 m^2, m=85 kg, C=1.0). The density of air is 1.21 kg/m^3.

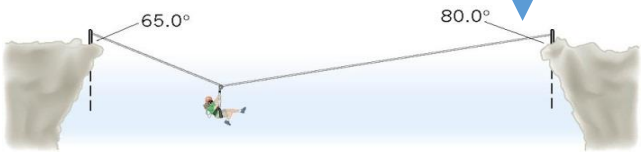
The helicopter in the drawing is moving horizontally to the right at a constant velocity. The weight of the helicopter is 53,800 N. The lift force L generated by the rotating blade makes an angle of 21.0° with respect to the vertical. What is the magnitude of the lift force?



A stoplight is suspended by two cables over a street. Weight of the light is 110 N and the cables make a 122° angle with each side of the light. Find the tension in each cable.



A mountain climber, in the process of crossing between two cliffs by a rope, pauses to rest. She weighs 535 N. Find the tensions in the rope to the left and to the right of the mountain climber.



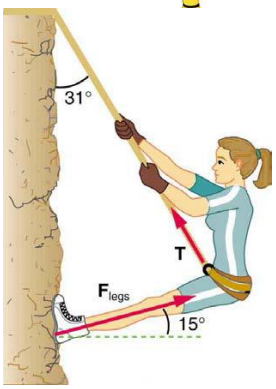
Physics 02-04 Tension, Hooke's Law, Drag, and Equilibrium *Name:* _____

A 10-g toy plastic bunny is connected to its base by a spring. The spring is compressed and a suction cup on the bunny holds it to the base so that the bunny doesn't move. If the spring is compressed 3 cm and has a constant of 330 N/m, how much force must the suction cup provide?

Homework

1. A stone is thrown from the top of a cliff. As the stone falls, is it in equilibrium?
2. During the final stages of descent, a sky diver with an open parachute approaches the ground with a constant velocity. The wind does not blow him from side to side. Is the sky diver in equilibrium, and if so, what forces are responsible for the equilibrium?
3. Why can a squirrel jump from a tree branch to the ground and run away undamaged, while a human could break a bone in such a fall?
4. A supertanker ($m = 1.70 \times 10^8$ kg) is moving with a constant velocity. Its engines generate a forward thrust of 7.40×10^5 N. Determine (a) the magnitude of the resistive force exerted on the tanker by the water and (b) the magnitude of the upward buoyant force exerted on the tanker by the water. (Cutnell 4.47) $\mathbf{7.40 \times 10^5\ N, 1.67 \times 10^9\ N}$
5. A stuntman is being pulled along a rough road at a constant velocity, by a cable attached to a moving truck. The cable is parallel to the ground. The mass of the stuntman is 109 kg, and the coefficient of kinetic friction between the road and him is 0.870. Find the tension in the cable.(Cutnell 4.51) **929 N**

6. (a) Calculate the tension in a vertical strand of spider web if a spider of mass 8.00×10^{-5} kg hangs motionless on it. (b) Calculate the tension in a horizontal strand of spider web if the same spider sits motionless in the middle of it. The strand sags at an angle of 12° below the horizontal. (OpenStax 4.19) $\mathbf{7.84 \times 10^{-4}\ N, 1.89 \times 10^{-3}\ N}$
7. Superhero and Trusty Sidekick hanging motionless from a rope. Superhero's mass is 90.0 kg, while Trusty Sidekick's is 55.0 kg, and the mass of the rope is negligible. (a) Draw a free-body diagram of the situation showing all forces acting on Superhero, Trusty Sidekick, and the rope. (b) Find the tension in the rope above Superhero. (c) Find the tension in the rope between Superhero and Trusty Sidekick. (OpenStax 4.34)**1420 N, 539 N**



8. Consider the 52.0-kg mountain climber in the picture. (a) Find the tension in the rope and the force that the mountain climber must exert with her feet on the vertical rock face to remain stationary. Assume that the force is exerted parallel to her legs. Also, assume negligible force exerted by her arms. (b) What is the minimum coefficient of friction between her shoes and the cliff? (OpenStax 5.17) **273 N, 512 N; 0.268**
9. A monkey (m = 4 kg)is in a harness connected to a rope that goes up over a pulley on the ceiling. If the monkey pulls on the other end of the rope, it will go up. It is the climbing at a constant velocity, what is the tension in the rope? (RW) **19.6 N**
10. A toy dart gun uses a spring to shoot a dart. (a) If you have to use 25 N to compress the spring 6 cm, what is the spring constant? (b) If it fires a 50-g dart, what will be the acceleration of the dart assuming no air resistance? (RW) **417 N/m, 500 m/s²**
11. An 80-kg bungee jumper jumps off a bridge. Rubber bungee cords act as a large spring attaching the jumper to the bridge. A bear standing in the river below catches the jumper. If the spring constant of the bungees is 20 N/m and they stretch 50 m. How much force must the bear apply to keep the jumper from moving? (RW) **216 N**
12. To maintain a constant speed, the force provided by a car's engine must equal the drag force plus the force of friction of the road (the rolling resistance). (a) What are the drag forces at 100 km/h for a Toyota Camry? (Drag area is 0.70 m²; C = 0.28) (b) If the friction is 235 N, what is force the engine provides to maintain a constant velocity? (RW) **91.5 N, 327 N**
13. The terminal velocity of a person falling in air depends upon the weight and the area of the person facing the fluid. Find the terminal velocity (in meters per second) of an 80.0-kg skydiver falling in a pike (headfirst) position with a cross-sectional area of 0.140m² and C = 0.70. (OpenStax 5.20) **115 m/s**
14. A 560-g squirrel with a cross-sectional area of 144 cm² falls from a 5.0-m tree to the ground C = 1.0. Estimate its terminal velocity. What will be the velocity of a 56-kg person hitting the ground, assuming no drag contribution in such a short distance? (Review) (OpenStax 5.22) **25.1 m/s, 9.90 m/s**