6.5: In Summary

1. Whenever two objects interact, they exert *forces* on each other that are equal in magnitude and opposite in direction (*Newton's 3rd law*).
2. Forces are vectors, and they are additive. The total (or net) force on an object or system is equal to the rate of change of its total momentum (*Newton's 2nd law*). If the system's mass is constant, this can be written as $F_{ext,all} = Ma_{cm}$, where M is the system's total mass and a_{cm} is the acceleration of its center of mass. Only the *external* forces contribute to this equation; the internal forces cancel out because of point 1 above.
3. For any interaction that can be derived from a potential energy function $U(x_1 - x_2)$, the force exerted by object 2 on object 1 is equal to $-dU/dx_1$ (where the derivative is calculated treating x_2 as a constant), and vice-versa.
4. The force of gravity on an object near the surface of the earth is known as the object's *weight*, and it is equal (in magnitude) to mg, where m is the object's inertial mass.
5. An ideal spring whose relaxed length is x_0, when stretched or compressed to a length x, exerts a pulling or pushing force, respectively, at both ends, with magnitude $k|x - x_0|$, where k is called the spring constant.
6. When dealing with macroscopic objects we introduce several "constraint" forces whose values need to be determined from the accelerations through Newton's second law: the *tension* F^t in ropes, strings or cables; the *normal force* F^n exerted by a surface in response to applied pressure; and the static friction force F^s that prevents surfaces from slipping past each other.
7. The maximum possible value of the static friction force is $\mu_s|F^n|$, where μ_s is the coefficient of static friction.
8. The force of sliding or kinetic friction, F^k, appears when two surfaces are sliding past each other. Its magnitude is $\mu_k|F^n|$ (μ_k is the coefficient of static friction), and its sign is such as to oppose the sliding motion. Unlike the forces in 6 above, it is a dissipative force.
9. A *free-body diagram* is a way to depict *all* (and *only*) the forces *acting on* an object. The object should be represented as a small circle or dot. The forces should all be drawn as vectors originating on the dot, with their directions correctly shown and their lengths approximately to scale. The acceleration of the object should also be indicated elsewhere in the picture. The forces should be labeled like this: $F^{type}_{by,on}$.