

1. Suppose a cold beer at 40°F is placed into a warm room at 70°F . Suppose 10 minutes later, the temperature of the beer is 48°F . Use Newton's law of cooling to find the temperature 25 minutes after the beer was placed into the room.
2. A murder victim is discovered at midnight at the temperature of the body is recorded at 31°C . One hour later, the temperature of the body is 29°C . Assume that the surrounding air temperature remains constant at 21°C . Use Newton's law of cooling (the differential equation $T' = k(A - T)$) to calculate the victim's time of death (when his body temperature was 37°C).
3. A parachutist of mass 60 kg free-falls from an airplane at an altitude of 5000 meters. He is subjected to an air resistance force proportional to his speed. Assume that the constant of proportionality is $r = 10$ kg/sec.
 - (a) Find and solve the differential equation governing the altitude of the parachuter at time t seconds after the start of his free-fall.
 - (b) Assuming he does not deploy his parachute, find his limiting velocity and how much time will elapse before he hits the ground (you may need to use a computer for this last part, a visual approximation from the appropriate graph is fine).
4. In our model of air resistance, the resistance force has depended only on the velocity. However, for an object that drops a considerable distance, such as the parachutist in the previous exercise, there is a dependence on the altitude as well. It is reasonable to assume that the resistance force is proportional to air pressure, as well as to the velocity. Furthermore, to a first-order approximation, the air pressure varies exponentially with the altitude (i.e., it is proportional to e^{-ax} , where a is a constant and x is the altitude). Propose and justify (*but do not solve!*) a differential equation model for the velocity of a falling object subject to such a resistance force.
5. For each of the first-order differential equations, decide whether it is linear or nonlinear. If the equation is linear, state whether it is homogeneous or inhomogeneous.
 - (a) $y' = ky$
 - (b) $y' = k(72 - y)$
 - (c) $y' = y(4 - y)$
 - (d) $y' = t + y$
 - (e) $3y' + 5y = 3 \cos 2t$
 - (f) $3y' + 5y = 3 \cos 2y$
 - (g) $y' = 4t^2y - \sin t$
 - (h) $y' = 4ty^2 - \sin t$