§2.1: **Work** – In-class examples and additional problems

(1) According to Newtons’ universal law of gravitation, the force between a planet of mass $M$ and a probe of mass $m$ is $F = \frac{G M m}{r^2}$, where $r$ is the distance between them and $G \approx 6.67 \cdot 10^{-11} m^3 kg^{-1} s^{-1}$ is the gravitational constant. Find the work required to launch a probe from the surface of a planet with radius $R$ to a height of 1000 km. What if we want to launch the probe all the way to infinity?
(2) A cable hanging over the edge of a tall building is 40 meters long and weighs 60 kilograms. How much work is required to pull 10 meters of cable to the top of the building?

(3) A 5-kilogram bucket containing 10 kilograms of water is lifted from the ground into the air by pulling in 20 meters of rope at a constant speed. The rope weighs 0.08 kilograms per meter. How much work was spent lifting the bucket and the rope?
(4) Suppose, in the previous problem, that the bucket is leaking water at a constant rate. It finishes draining just as the bucket reaches the top. How much work was spent lifting the bucket and rope?

(5) A rectangular swimming pool measures 25 meters by 15 meters and is 9 meters deep. It is full of water, the density of which is 1000 kg/m$^3$. How much work is required to empty the pool by pumping the water over the side?
(6) A conical tank measuring 10 meters high with base diameter 8 meters is full of a liquid which has density 810 kg/m$^3$. How much work does it take to pump the kerosene out of a spigot 1 m above the top of the tank?
(7) The graph of $y = x^2$ from $x = 0$ to $x = 2$ is revolved about the $y$-axis to form a tank that is then filled with salt water from the Dead Sea (which has density approximately 1200 kg/m$^3$). Assume that $x$ and $y$-values are measured in meters. How much work does it take to pump all of the water to the top of the tank?
(8) A right-circular cylindrical tank of height 10 meters and radius 5 meters is lying horizontally and is full of diesel fuel with density 900 kg/m$^3$. How much work is required to pump all of the fuel to a point 5 meters above the top of the tank?