Homework 37

The **due date** for this homework is **Tue 7 May 2013 12:00 AM EDT**.

Question 1

How much work is needed to lift a $40\ \mathrm{kg}$ television up a height of 2 meters? Take the acceleration of gravity to be $g = 10\,\mathrm{m/s^2}$.

A reminder on units: recall that, in the International System of Units, length is measured in meters (m), time in seconds (s), and mass in kilograms (kg). The unit of force is called a newton (N), and that of work a joule (J). Newton's Second Law, $F = ma$, tells us that

$$1\,\mathrm{N} = 1\,\mathrm{kg\,m/s^2}$$

The basic definition of work as a product of force and distance then yields

$$1\,\mathrm{J} = 1\,\mathrm{N\,m} = 1\,\mathrm{kg\,m^2/s^2}$$

- $1{,}000\,\mathrm{J}$
- $800\,\mathrm{J}$
- $40\,\mathrm{J}$
- $80\,\mathrm{J}$
- $1{,}600\,\mathrm{J}$
- $400\,\mathrm{J}$

Question 2

Your swimming pool is $3\,\mathrm{m}$ deep, $10\,\mathrm{m}$ long and $6\,\mathrm{m}$ wide. If the pool is initially full, how much work is required to drain two-thirds of the water in the pool (that is,

until the water is only $1\,\mathrm{m}$ deep)? Assume that the density of water is $1{,}000\,\mathrm{kg/m^3}$, and that the acceleration of gravity is $g = 10\,\mathrm{m/s^2}$.

- $1.35 \cdot 10^6\ \mathrm{J}$
- $1.25 \cdot 10^5\ \mathrm{J}$
- $2.7 \cdot 10^5\ \mathrm{J}$
- $2.4 \cdot 10^4\ \mathrm{J}$
- $1.2 \cdot 10^6\ \mathrm{J}$
- $1.2 \cdot 10^5\ \mathrm{J}$

Question 3

A 100 meter long cable of linear mass density $0.1\,\mathrm{kg/m}$ hangs over a very high vertical cliff. Assuming that there is no friction, how much work is needed to to lift this cable up to the top of the cliff? Assume that the acceleration due to gravity is $g = 10\,\mathrm{m/s^2}$.

- $500\,\mathrm{J}$
- $2{,}500\,\mathrm{J}$
- $5{,}000\,\mathrm{J}$
- $50\,\mathrm{J}$
- $100\,\mathrm{J}$
- $10{,}000\,\mathrm{J}$

Question 4

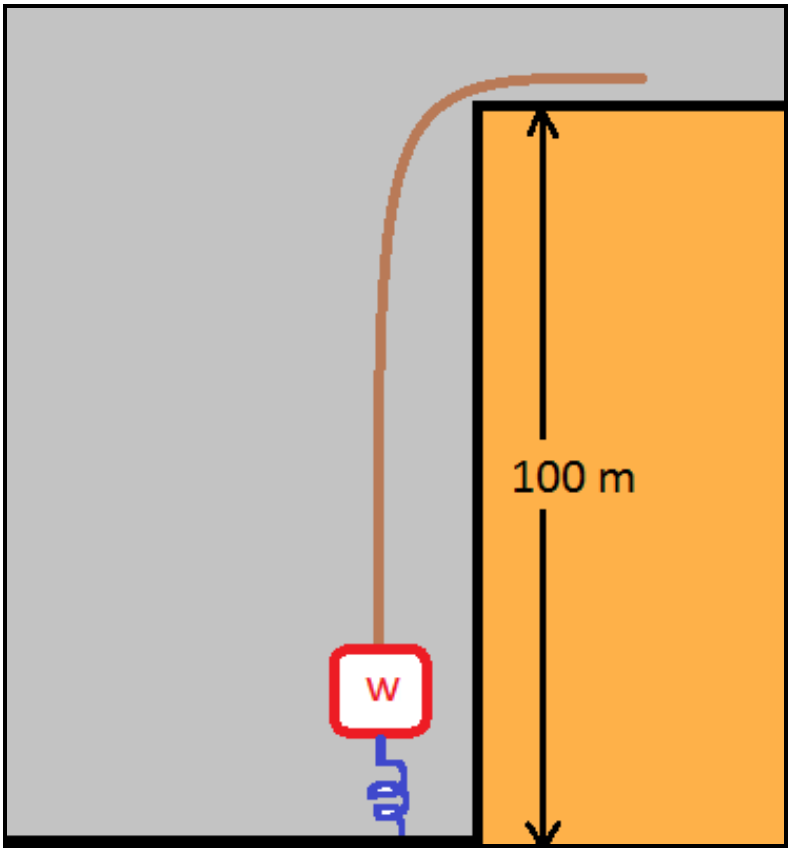
Assume that a sports car's acceleration a increases linearly with its position x as $a(x) = x$. Since the car is burning fuel, its mass m decreases; assume the decrease is exponential in x as $m(x) = 1 + e^{-x}$. How much work is done in driving the car from $x = 0$ to $x = 3$?

Hint: remember Newton's Second Law, $F = ma$. In our case, both mass and acceleration are functions of x.

- $3 + \frac{3}{e^3}$
- $3e^2 - 1$
- $1 - \frac{2}{e}$
- $\frac{9}{2} + \frac{2}{e^3}$
- $\frac{2}{e^2}$
- $\frac{11}{2} - \frac{4}{e^3}$

Question 5

An object w of negligible height and weight has been suspended between a rope and a spring from a $100\ \mathrm{m}$ high cliff as shown in the picture. How much work is required to pull w up from the base of the cliff up to a height of $6\ \mathrm{m}$?



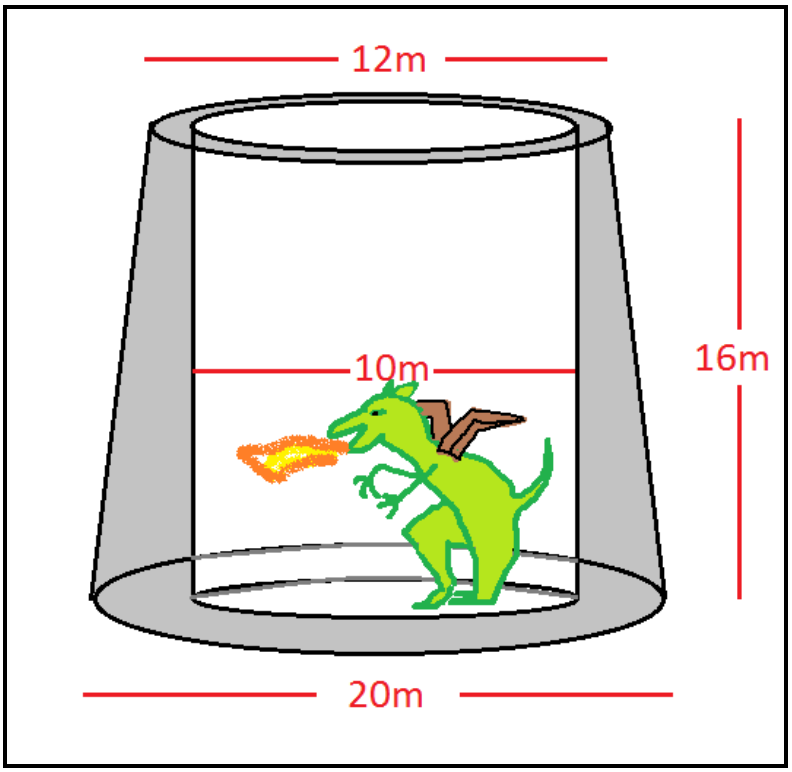
You may assume that the rope has a constant mass density of $0.1\,\mathrm{kg/m}$ and that the spring is *hard*, with force $F_{\text{spring}}(x) = 2x + 3x^2$ (in newtons) where x is the distance in meters of w up from the ground. Take the acceleration of gravity to be $g = 10\,\mathrm{m/s^2}$.

- $417\,\mathrm{J}$
- $834\,\mathrm{J}$
- $1{,}176\,\mathrm{J}$
- $652\,\mathrm{J}$
- $900\,\mathrm{J}$
- $270\,\mathrm{J}$

Question 6

A knight wants to build a tower to imprison a dragon. This tower will have a height

of $16\,\mathrm{m}$. Each horizontal cross-section of the prison will be an annulus with inner diameter $10\,\mathrm{m}$. The walls will be $5\,\mathrm{m}$ thick at the base of the tower, sloping linearly up so they are $1\,\mathrm{m}$ thick at the top of the tower.



The tower will be built of stone whose (mass) density is $30\,\mathrm{kg/m^3}$. How much work must the knight do in order to erect the tower if all the stone starts at the base of the tower and the acceleration of gravity is assumed to be $g = 10\,\mathrm{m/s^2}$?

- $200{,}000\pi$ J
- $577{,}600\pi$ J
- $1{,}055{,}200\pi$ J
- $180{,}000\pi$ J
- $144{,}000\pi$ J
- $1{,}139{,}200\pi$ J

☐ In accordance with the Honor Code, I certify that my answers here are my own work.

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