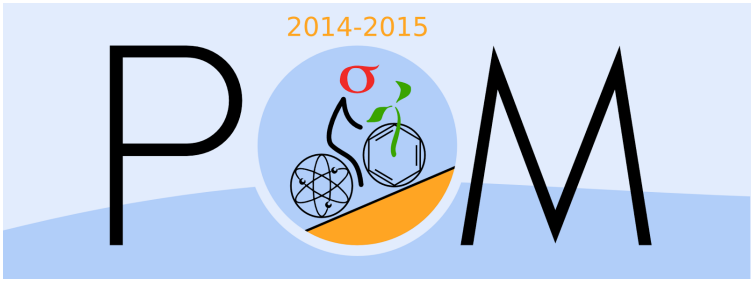
PROBLEM OF THE MONTH



NOVEMBER, 2014

MATHEMATICS

5 points:

Is it possible to place 4 soccer players on a soccer field so that pairwise distances between them are equal to 1, 2, 3, 4, 5, and 6 meters?

10 points:

Given an equilateral triangle ABC find all points M on the plane such that both triangles ABM and ACM are isosceles.

PHYSICS

5 points:

A person stays on scales in the elevator, which is initially at rest. The elevator begins moving upwards, and first moves with a constant acceleration for two seconds. After that, it moves up with a constant speed. Before coming to rest, the elevator decelerates for 3 seconds, again with a constant acceleration.
The reading of the scales was 60 kg during acceleration, and 40 kg during deceleration. What is the mass of the person?

10 points:

The maximum speed with which a car can stay on a flat, horizontal circular road of radius R=50m without skidding, is v_0=20m/s. Find the minimum time it will take this car to stop on a straight road, if it moves with speed v_1= 30m/s.

CHEMISTRY

5 points:

Plutonium is a radioactive element, which is extremely harmful to humans not only due to its radioactivity, but also due to its high toxicity. Imagine you took 1 gram of plutonium (III) chloride and dissolved it in 10 L of water. Obviously, this solution is extremely dangerous and toxic. Then you took 100 mL of this solution and added 9.9 L of pure water to it. The solution obtained is less toxic, but it is still toxic. You took 100 mL of this solution and again added 9.9 L of water to it. How many times do you need to repeat this operation until the expected number of Pu atoms in the final solution is no more than 1?

10 points:

Imagine you are in a chemistry laboratory with the standard equipment. The only chemicals available to you are carbon (charcoal) and another element of your choice. You can use any equipment you want, as well as an unlimited amount of water, air and electricity. Catalysts, which are not consumed in your reactions, are also considered as equipment.

Using these materials and equipment, prepare as many different chemical compounds as possible. “Prepare” means to draw the equation, or a series of equations describing a chemically plausible chemical reaction leading to a desired substance.

BIOLOGY

5 points:

In 1774 - 1775, British scientist Charles Blagden conducted a series of experiments in a "super-sauna", a heated chamber he built to measure what is the highest temperature a living creature could bear. He himself, his assistants, and his dog appeared to be capable of sustaining a temperature as high as 127 degrees Celsius for 20 minutes. To prove that there was no mistake in temperature measurements (in those time thermometers were not as precise as modern devices are) he took twenty eggs and a fat juicy steak with him into his "super-sauna", and he found that after twenty minutes the eggs were roasted quite hard, and the meat was rather overdone.

However, neither the scientists nor the dog were negatively affected by this extreme heat. From this experiment, Blagden concluded that human and animal organisms possess some mechanisms that allow them to fight extreme heat and to maintain a constant body temperature.

Please answer the following questions:

1. What is the mechanism that allows a human body to get rid of excess heat?
2. Do dogs utilize the same mechanism? If not, what mechanism do dogs use for thermoregulation?
3. What other mechanisms of thermoregulation are used by animals?

10 points:

It is common in zoology and ecology to divide animals into carnivores and herbivores. This classification allows us to distinguish animals that rely on thoroughly different food sources.

1. What are the physiological differences between carnivores and herbivores?
2. How do carnivores and herbivores differ in the enzymes that they make?
3. How do you think omnivores (animals that can eat both meat and plants) are different from the above mentioned groups?

COMPUTER SCIENCE

Solutions must be typed and submitted in one of following formats:
.txt .c .cpp .java .py
Solutions written in Java, C, C++, Python and pseudo-code are accepted.
Pseudo-code guidelines are at
http://users.csc.calpoly.edu/~jdalbey/SWE/pdl_std.html

5 points:

Define a procedure that takes a list of numbers as input and returns the sum of the squares of the input values that are even.
(Hint: You can test whether a number is even by seeing if the number mod 2 is 0, that is, x % 2 == 0)

10 points:

An astronaut is on a cylindrical spaceship with M airlocks (exits) positioned around in a circle. He needs to exit one of the airlocks, go all the way around in a circle, and come

back through the same airlock. He has a limited capacity oxygen tank: a completely filled tank is only enough to last him 600 seconds. There is an oxygen source at each airlock where the astronaut can re-fill his tank.

You are given:
n = the number of airlocks, numbered 0 to n-1.

job[n] = an array of size n, where job[2] represents the time it takes from the astronaut to get from airlock 2 to airlock 3. If there are 6 airlocks, then job[5] = time to go from airlock 5 to airlock 0.

oxygen[n] = the number of seconds of oxygen available for refill at airlock [n]. Upon arriving to airlock n, the astronaut can re-fill his tank, but his tank still cannot exceed the 600 second capacity.

Task:
Determine whether the astronaut can complete his task without having to get back into the spaceship to re-fill his tank. That is, is there an airlock that he can exit through and go in either direction so that he can make it all the way around and re-enter through the same airlock without running out of oxygen? If it is impossible, output “no”. If it is possible, output the number of an airlock that he can exit.

Example 1:
Input:
n = 4
job[] = [700, 100, 100, 100]
oxygen[] = [100, 100, 500, 500]

Output: “No”. (This is because job[0] = 700, which is greater than the tank’s capacity.)

Example 2
Input:
n = 4
job[] = [100, 500, 100, 100]
oxygen[] = [100, 0, 100,0]

Output: “Yes”. The astronaut starts at airlock 1, uses up 500 of his 600 of oxygen, refills back to 200 at n=2, uses up 100, left with 100, cannot refill at n=3, uses up 100, left with

0, refills to 100 at n = 0, uses up 100 to get to n = 1, and gets back into the spaceship with no oxygen left.