MATHEMATICS

5 points:

Three friends are deciding who is going to run to the store to get bagels. How could they choose one of them fairly by flipping a coin?

10 points:

It is known that some family has two children. It is also known that one of them is a boy born on Tuesday. What is the probability that the other child is a boy as well?

Note: This is a math problem. Therefore, assume that the probability of a single child being a boy is 50% and that having birth on any day of the week is equally probable.

PHYSICS

5 points:

An egg is dropped from the top of a very high building. As the speed of the egg increases, the force of air resistance changes proportionally to this speed squared: $F_{air} = kv^2$ (here v is the speed and k is certain unknown constant). As a result, the egg first accelerates but eventually reaches a constant speed $v_0 = 40m/s$ (called terminal velocity).
Find the acceleration of the egg at the moment when its speed was $v = 30m/s$.

10 points:

A pendulum is made of a string and a mass *m* attached to it. Initially, the mass is held so that the string is horizontal. The mass is released with no initial speed, and the

pendulum starts to oscillate. Find the maximum tension in the string during these oscillations. Neglect air resistance or any other energy loss.

CHEMISTRY

5 points:

LZ 126 *Hindenburg* was a commercial passenger airship (dirigible). It was used on regular transatlantic flights connecting Germany and the US (New Jersey) from 1936 till 1937. *Hindenburg* made 63 flights, and it was destroyed in a catastrophic fire during landing. 62 passengers and crew perished during this tragic incident.
What was the reason of the fire, and was it possible to change *Hindenburg's* design to eliminate a possibility of fire? Was it possible to make a dirigible with exactly the same size and payload? If the answer is yes, prove it by making necessary computations, if the answer is no, calculate the maximal payload of the modified *Hindenburg.*

10 points:

Al kohl (the 'kohl') is an Arabic alchemical term that was initially used to describe a tiny and volatile powder obtained after heating some minerals. Later, the alchemists, both in the East and in Europe, used this term to describe any volatile substances obtained after heating liquids or solids followed by condensation of the vapors formed. In English, this term later transformed into 'alcohol', and it is used now mostly for ethanol (ethyl alcohol). Ancient alchemists believed by heating wine, and by collecting and condensing the vapors, they obtain a 'spirit' of vine, or its 'essence'. Accordingly, the Medieval Latin name of ethyl alcohol was *spiritus vini*, or 'the spirit of vine'. By the way this name, was preserved in many European languages (German *spitirus*, Spanish *espiritu*, Russian *спирт* (pronounced *'speert'*), Italian *spirito,* etc).
Besides *spiritus vini,* Medieval alchemists obtained other *spirits*. They did that by heating various substances, or mixtures of substances, and by collecting the vapors formed during that process. Please, name as many these *spirits* as possible, and give their modern names. It would be good if you provided the equations of the corresponding chemical reactions.
Happy googling!

BIOLOGY

5 points:

Around 300 BC a physician from Alexandria named Herophilus was studying human anatomy and physiology. He concluded that the brain is the organ which performs thinking. What observations could lead you to the same conclusions?

10 points:

Unicellular organisms are extremely successful in their environments and, under the right conditions, can reproduce rapidly. Why do you think multicellular life has developed and became so widespread?

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:
Problem 1

Given a 4-digit integer print whether all the digits are different or not.

10 points:
Problem 2

You are given a chess-board with various pieces at specified locations. You have a knight at square (a, b). Determine if it is possible to move the knight to square (i, j) without moving any other pieces. The knight can make any number of moves. 1-2 points will be awarded for finding the smallest number of moves needed.

Hint: First, write the algorithm to see if you can do it in just a few moves, say, at most 2.

Technical details: You can define variables that define your chess board however you like, but make sure to write a few sentences in the comments of your code that explain your setup. One way to store the data about pieces on the board is to define a 2D array where 0 corresponds to empty square, and 1 corresponds to "occupied by a piece that is not the knight" (all pieces except for the knight are there just to take up space).