Cougar Programming Contest

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10:30a-12:30p

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Programming Packet

DO NOT OPEN UNTIL TOLD TO DO SO

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UNIVERSITY OF HOUSTON
CULLEN COLLEGE OF ENGINEERING

Freshmen 15

Problem: A well known fact about college students is that we tend to eat a little on the unhealthy side. Engineering students tend to prefer pizza due to its relatively low cost and high convenience. Given that:

1. each slice of pizza is 300 calories, and
2. for the average person 3000 calories is one pound,

calculate how many days it will take to “put on” the freshmen fifteen based on an input number of slices per day.

Sample Input:

```
10
```

Sample Output:

```
At 10 slices of pizza per day, it will take 15 days to put
on the freshmen fifteen.
```

Binary Conversion

Problem: A Electrical Engineers are expected to know binary conversions by heart for reasons too many to list and too obvious to mention. Given a positive integer guaranteed to fit within 16 bits convert the number to its binary representation.

Sample Input:

```
17
```

Sample Output:

```
Base 10: 17
Base  2: 10001
```

2.3

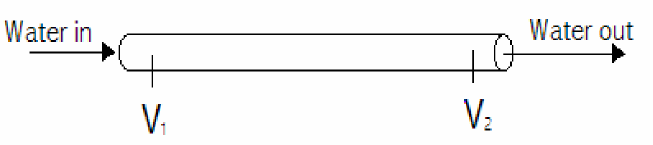
Water Pumping

Problem: Mechanical engineers are often evolved in designing pumps which provide a pressure increase in a pipeline. As water flows through a pipe it eventually looses some pressure. In order to determine the power required for a pump that will increase the pressure in a pipeline the mechanical engineer must determine the pressure drop or the pressure lost over a length of pipe. One may use Bernoulli’s equation for such a calculation:

$$\Delta P = \frac{V_1^2 - V_2^2}{2}\rho$$

where V_1 and V_2 are the velocities at point 1 and point 2 on a pipe respectably in cm per second, ρ = 1g/cm^3 (the density of water) and ΔP is the pressure drop in . Write a program that will calculate the pressure drop along a pipe for water.

Note: V_1 is always larger than V_2.



Sample Input:

```
25
15
```

Sample Output:

```
V1 = 25 cm/s
V2 = 15 cm/s
DP = 200 g/cm*s^2
```

Drop One!

Problem: Students generally feel that engineering is a challenging subject and professors are often told that as well. To make up for this, professors usually drop the lowest quiz grade and replace it with the highest quiz grade.

Write a program that will accept 4 test grades and compute the average. The program should also replace the lowest quiz grade with the highest quiz grade. If 2 grades are equally low then only 1 will be replaced.

Sample Input:

```
100 50 80 80
```

Sample Output:

```
Grade dropped: 50
New average: 85
```

Ohm’s Law

Problem: Within the many equations electrical engineers are responsible for knowing, none are more basic (and thankfully, easy to remember) than Ohm’s Law. Mr. George Ohm realized in 1827 that the voltage across a device is equal to the current flowing through the device multiplied by the resistance of the device. More easily stated:

$$V = I * R ,$$

where I is the value of current, R is the value of resistance and V is the value of voltage. Given the value of I in milliamps and R in kilo ohms, calculate the value for voltage and output in Volts.

Sample Input:

```
10 20
```

Sample Output:

```
I = 10 [mA]
R = 20 [kO]
V = 200 [V]
```

Antoine's Equation

Problem: Chemical Engineers often need to calculate the saturated temperature of a chemical at a specified pressure. If the formula for this calculation is,

$$T^{sat} = \frac{B}{A - \ln P} - C \quad \text{(Antoine's equation)}$$

were T^{sat} is the saturated temperature in °C and P is the pressure in mmHg. Each chemical has specific values for A, B, and C based on their chemical properties. Write a program that will calculate the saturated temperature for various chemicals at different pressures. Input will be A, B, C, followed by several values for P.

Sample Input:

```
16.6513
2940.46
237.22
610
10
```

Sample Output:

```
A = 16.6513
B = 2940.46
C = 237.22

P = 610
Tsat = 50.00

P = 10
Tsat = -32.29
```

5.1

Exact Change

Problem: Engineers tend to be pressed for time as it is without professors lecturing past class time. We are often reduced to eating a meal out of the vending machine (this might be related to the Freshmen 15 problem) but rarely have exact change. Assume that I only have dollar bills and always have enough money to purchase the item my sweet tooth is craving. Calculate the number of bills I should insert and the amount of change I should get back so that I can be sure the machine did not short me.

Sample Input:

```
0.85
```

Sample Output:

```
Food Price: $ 0.85
Insert one dollar bill.
Receive one dime, one nickel.
```

5.2

Allocating Study Time

Problem: A common scenario you will encounter while studying engineering is to find time to study for exams. One way to deal with this is to randomly assign a task to each day of the week and do it.

Write a program that randomly generates number for you so that you can allocate a task to do each day of the week. Use the following list.

1. Study
2. Beer
3. Significant other
4. Beer
5. Study
6. Movies
7. Beer

If you get at least 1 study, then generate a message saying you passed the course. If you get 2 or more beers, then generate a message saying you failed despite the number of studying you get.

The input is the seed to the random number generator.

Sample Input:

```
0
```

Sample Output:

```
Day 1: Study
Day 2: Movies
Day 3: Significant other
Day 4: Beer
Day 5: Beer
Day 6: Study
Day 7: Study

Too much beer, you failed the exam.
```

CPU Performance

Problem: Computer performance is expressed in several terms and these must all be taken into consideration when choosing architectural changes. A CPU is rated on cycles per second and instructions per cycle. The first line will contain the number of instructions in a test program (given in thousands). The second line will contain the specs of the original processor in cycles per seconds (given in megahertz) and cycles per instruction. Following that will be the number of inputs to follow, followed by new processor specs. Calculate the time in milliseconds each processor uses to run the program and its percentage improvement.

$$\textit{Execution time} = \frac{\textit{Seconds}}{\textit{Cycle}} * \frac{\textit{Cycles}}{\textit{Instruction}} * \frac{\textit{Instructions}}{\mathrm{Pr}\,\textit{ogram}}$$

Note: Cycles per second is more commonly referred to as Hz, MHz, or GHz.

FYI : Mega = 10^6 or 1000000
Kilo = 10^3 or 1000
Milli = 10^-3 or 0.001

Sample Input:

```
100
450 2.0
2
400 1.5
500 2.0
```

Sample Output:

```
Original Processor Time: 0.444 msec
New Processor #1 Time:   0.375, a 15.5% improvement
New Processor #2 Time:   0.400, a 9.9% improvement
```

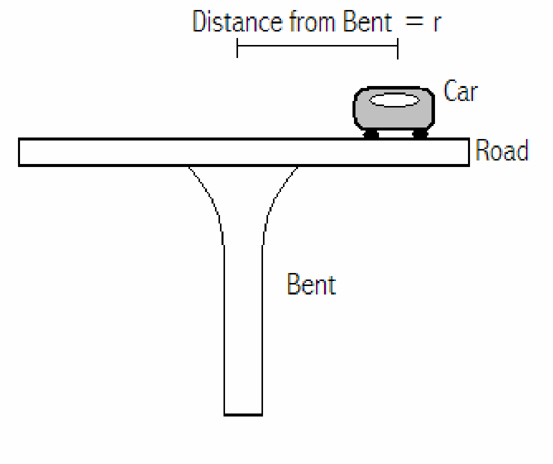
Bridge Design

Problem: Mechanical and Civil Engineers are concerned with the physics of structures that hold large loads. An example of one is a bent. Bents are used to hold up an elevated road like a freeway. To design a bent the engineer must consider the potential moments of inertia, or force from a distance, that would be applied to the bent by passing cars. If the car is at a distance defined by r and the car exerts a force F on to the bent then the moment of inertia is r times F :

$$M = r * F$$

Write a program that will calculate the moment of inertia applied to the bent for various distance and masses of cars.

Note: F = mg, where m is the mass of the car in grams and g = 9.8 m/s^2 (the acceleration of gravity in meters per seconds squared).



Sample Input:

```
2.5
508
```

Sample Output:

```
R = 2.5 m
m = 508 kg

M = 12446 Nm
```

5.5

Binary Conversion Revisited

Problem: There are several methods for representing signed numbers in computers. One very common method is known as two’s complement. This method is convenient because it allows us to subtract numbers by simply adding one number to the other’s two complement, thereby reducing complexity in the CPU design. In two’s complement a positive number’s binary representation is a trivial conversion. However, a negative number is represented by completing the following steps:

1. Ignore the sign and covert the number to binary representation.
2. Change all 1’s to 0’s and all 0’s to 1’s.
3. Add the value 1 to the result of (2).

Given an input integer guaranteed to fit with 8 bits, calculate the two’s complement of the number.

Sample Input:

```
-68
```

Sample Output:

```
10111100
```

Vector Analysis

Problem: In all engineering disciplines, the concept of vector analysis is very important. One of the most basic concepts of vector analysis is the cross (vector) product.

The cross product works as follows. Suppose we have the 2 vectors:

A = 2i – 9j + 7k
B = 0i + 3j + 1k

A X **B =**

i	j	k
2	-9	7
0	3	1

A X **B** = [(-9 * 1) – (3 * 7)]i – [(2 * 1) – (0 * 7)]j + [(2 * 3) – (0 * -9)]k
A X **B** = -30i – 2j + 6k

Write a program that will compute the cross product of 2 vectors.

Sample Input:

```
2 -9 7
0 3 1
```

Sample Output:

```
-30 -2 6
```

Numerical Differentiation

Problem: Engineers often need to know the derivative of a function (also know as the slope or rate of change). Usually we want a computer to calculate the derivative for us. Symbolic derivation is left to mathematicians but estimating the derivative is often close enough for engineers. A numerical differentiation can be made by evaluating a function at several points and calculating the derivative based on the following equation:

f'(x) = (f(x)-f(x-h)) / (x-(x-h))

Write a program to calculate the differential of

f(x) = x^3 + 2.7 * x^2 + 1.54 * x^1 + 0.17

at any input x and h pair of values.

Sample Input:

```
1.4 .2
```

Sample Output:

```
x = 1.4
h = 0.2
f'(x) = 13.6400
```

Multiplication by Bit Rotation

Problem: In your computer science class you may or may not have heard that multiplication is a rather inefficient operation for computer processors to carry out. However, a quick operation is to rotate bits in the binary representation of the number. Shifting bits one bit to the left results in multiplication by 2^1 or 2. Shifting two bits to the left results in multiplication by 2^2 or 4. This continues ad infinitum. Therefore, many multiplication operations can be carried out by breaking the multiplicand into powers of 2 and adding or subtracting them. For example multiplying 2*3 can be accomplished by multiplying 2 by 4 and then 2 by 1 and subtracting.

2 * 3 = 2 * 4 – 2 * 1

Given two number to be multiplied, output how the computer can modify the multiplication to make it realizable using bit shifting. You can assume that we will not give a problem requiring more than one subtraction or addition, as is the case above.

Sample Input:

```
3 5
```

Sample Output:

```
3 * 5 = 3 * 4 + 3 * 1
```

Machine Code

Problem: One of the most monotonous chores engineers must perform is the translation of assembly code to machine code. This will be done for an extremely reduced instruction set in this problem. Given the following format:

Instruction	Destination	Value
2 bits	4 bits	10 bits

The types of instructions are LD (load) and ST (store). The instruction value for LD is 1 and ST is 2. The destination can be any value from 0 to 15, and the value is the number to be stored in the destination.

Given an assembly command convert it to a binary machine instruction.

Sample Input:

```
LD 2 8
```

Sample Output:

```
01 0010 0000001000
```

Computer Memory

Problem: Most processors today require that their memory be aligned in order to achieve the best performance. Computer memory can be allocated in several sizes: bytes, half words (two bytes), and words (four bytes). Whenever a program declares variables it must make sure that bytes start on addresses divisible by one, half words on addresses divisible by 2, and words on addresses divisible by 4. Input a series of memory sizes that must be allocated and assign them names starting with ‘a’ and increasing incrementally. Anytime you need to skip address space print space(n) where n is the number of bytes skipped so that the next variable aligns correctly. To help you understand the example problem, a table is shown to the right, this is not necessary in your coding solution.

Sample Input:

```
Byte
Halfword
Byte
Byte
Word
```

Sample Output:

```
A = 0000
Space(1)
B = 0002
C = 0004
D = 0005
Space(3)
E = 0008
```

Addr	Contents
0	A
1	Empty
2	B
3	B
4	C
5	D
6	Empty
7	Empty
8	E
9	E
10	E
11	E

What's my GPA?

Problem: When calculating a college student's GPA both the grade and number of hours must be considered. Each line will contain a student's last name followed by a series of pairs of grade letter and number of hours. Calculate each student's GPA and output the list sorted by GPA in descending order.

Sample Input:

```
2
SMITH A 4 A 3 A 4 B 3
DOE C 3 D 1 A 1 B 3 C 4
```

Sample Output:

```
SMITH 3.79
DOE 2.67
```

Vector Analysis Revisited

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A X **B** = [(-9 * 1) – (3 * 7)]i – [(2 * 1) – (0 * 7)]j + [(2 * 3) – (0 * -9)]k
A X **B** = -30i – 2j + 6k

Write a program that will compute the cross product of 2 vectors.

Sample Input:

```
2i-9j+7k
0i+3j+1k
```

Sample Output:

```
-30i–2j+6k
```