PROBLEM OF THE MONTH POM **December, 2017**

2017-2018

MATHEMATICS

5 points:

A large experimental scientific facility began operation in 2007, collecting 1 Terabyte (TB) of data that year.The amount of data newly collected each following year was double the amount of all the data accumulated prior to that year. How much data will the facility have accumulated by the end of this year, 2017? How much data will there be by the end of 2027?

Hint: At the end of 2008, there were 2 TB new data collected, and 1TB from the previous year, i.e. 3 TB total. How much will there be at the end of 2009? Try to figure out a general rule.

Answer: $3^{10} = 59049$ TB in 2017, and $3^{20} = 3486784401$ TB in 2027.

Solution: The total amount of collected data triples each year. Therefore, the will be $3^{10} = 59049$ TB by the end of 2017, and $3^{20} = 3486784401$ TB by the end of 2027.

10 points:

Find all solutions of the following equation:

$$f(f(f(....f(x)))...) = x$$

$$2017\ times$$

Where the function which is successively applied 2017 times is $f(x) = \sqrt{4x^2 - 1}$

Hint: Try to solve equation $f(x) = x$. After that, you can demonstrate that (i) you found a solution for the original problem, and (ii) there are no other solutions. Alternatively, you can find the function $(f(f(....f(x)...))$

Answer: $x = 1/\sqrt{3}$

Solution: First, note that multiple consecutive application of a function, $g(x) = \sqrt{ax^2 + b}$, does not change the power of x under the square root: $g(g(x)) = \sqrt{a(ax^2 + b) + b} = \sqrt{cx^2 + d}$, $g(g(g(x))) = \sqrt{fx^2 + g}$, …, $g(g(...g(x))) = \sqrt{px^2 + q}$. Hence, the equation, $\underset{2017\ times}{f(f(f(....(f(x))...))) = x}$, is a quadratic equation and therefore has at most two solutions. Further, we note that this equation is satisfied by any x, which satisfies the equation $f(x) = x$, because it then it follows that $x = f(x) = f(f(x)) = ... = f(f(f(...(f(x))...)))$. Now, let us solve the equation, $f(x) = x$. It is also a quadratic equation, which is equivalent to $3x^2 - 1 = 0$, or, $x = 1/\sqrt{3}$, where we chose positive root because x is positive. This exhaust all solutions.

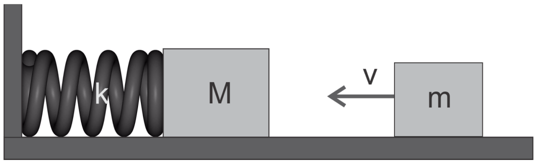
PHYSICS

This month Physics problems are on the momentum and energy conservation. You might find the following links useful.
http://hyperphysics.phy-astr.gsu.edu/hbase/ke.html
http://hyperphysics.phy-astr.gsu.edu/hbase/pegrav.html
http://hyperphysics.phy-astr.gsu.edu/hbase/mom.html
http://hyperphysics.phy-astr.gsu.edu/hbase/conser.html#conmom
http://hyperphysics.phy-astr.gsu.edu/hbase/elacol.html

5 points

A block of mass m is moving with the velocity V on a flat surface without a friction, and collides with another block of mass $M = 2m$, standing on the same surface and attached to the rigid horizontal wall through a massless spring with the spring constant k. Find the the maximum compression of the spring after absolutely inelastic collision* of the blocks.

* The phrase “absolutely inelastic collision” essentially means that blocks stick together after the collision.



Hint: Use conservation of momentum for the collision and then conservation of energy.

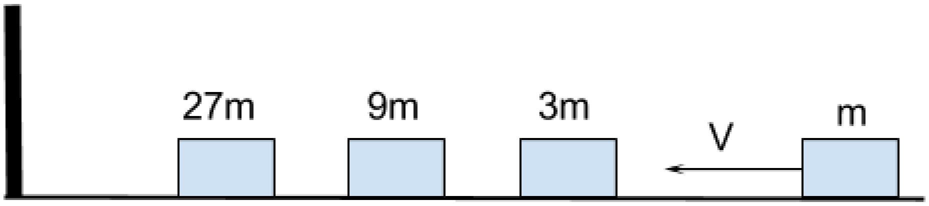
Answer: $x = V\sqrt{\frac{m}{3k}}$

Solution: For the collision we write $mV = (m+M)V'$and find $V' = V/3$. Then we write the conservation of energy for spring compression $\frac{(m+M)V'^2}{2} = \frac{kx^2}{2}$. We find $x^2 = \frac{mV^2}{3k}$ and, finally $x = V\sqrt{\frac{m}{3k}}$.

10 points

A block of mass m is moving with the velocity V on a flat frictionless surface towards three blocks of masses $3m,\ 9m,\ 27m$ arranged along the straight line in the order shown in the Figure. Find the velocities of all blocks after all collisions between blocks and the wall (see the Figure) take place. Assume that all collisions are absolutely elastic*.

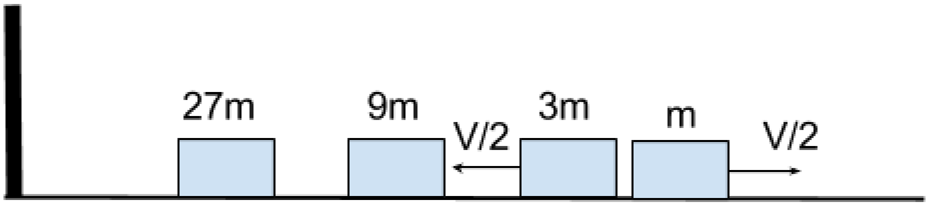
* The phrase “absolutely elastic collision” means that mechanical energy is conserved during the collision.



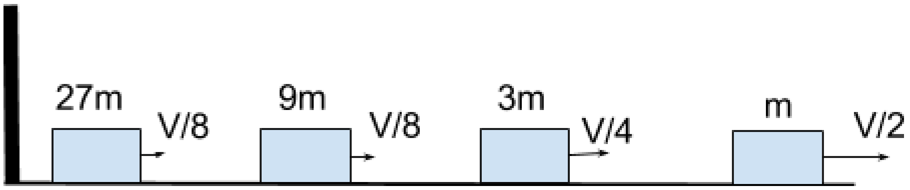
Hint: Find the result of the collision of mass m and 3m using both conservation of momentum and energy.

Answer: $V/8,\ V/8,\ V/4,\ V/2$

Solution: We write the conservation of momentum for the first collision $mV = mV_1 + 3mV_2$ and the conservation of energy for the same collision $\frac{mV^2}{2} = \frac{mV_1^2}{2} + \frac{3mV_2^2}{2}$. Here $V_{1,2}$ are the velocities of the first block and the second block right after collision, respectively. Solving these equations we obtain $V_1 =- V/2$ and $V_2 = V/2$.



It is clear that after the second collision the mass $3m$ will bounce to the right with velocity $V/4$ etc. We obtain that after all collisions (including one with the wall, which just reverts the velocity of the last mass) we obtain the following set of velocities from left to right $V/8,\ V/8,\ V/4,\ V/2$.



CHEMISTRY

Introduction to both problems.

Karel Čapek (1890–1938), a Czech playwright and novelist, is best known as the author of the very successful satirical plays R.U.R. (Rossum's Universal Robots) (1920) which gave the word 'robot' to the languages of the world. Besides that, he authored many novels that can formally be considered science fiction novels, although they are not just SciFi.

For example, in his novel *Krakatit*, which, for some reason is considered merely a satires on misused science he tells an amazing and fascinating story of a talented inventor named Prokop, who is desperately trying to find his only love and at the same time to save the world from the devastating weapons ("*Krakatit*") that he created and that fell into hands of irresponsible criminals. In the beginning of the novel, Prokop, who fell ill as a result of his experiments, tells his friend Tomasz, in delirium, about his research:

"*...Look, I've been working for twelve years now."*

"What does that give you?" - Tomasz objected sharply.

"Well, something happens. I sold explosive dextrin this year."

"How much?"

"Ten thousand. But it is, trifles. Just some lousy explosive for mines. If I wanted to ..."

"Are you better now?"

"Wonderful! I found such methods ... You know, my friend, just cerium nitrate - strong, a bastard! And chlorine, chlorine, tetraphase of nitrogen chloride explodes with light. You light a light bulb - and trrrah! But that's nothing but a trifling. Listen", - he suddenly blurted out, thrusting out from beneath the blanket a thin, terribly mutilated hand. "I have to take something in my hands, and I ... feel the movement of atoms. Like goosebumps. And every substance tickles in its own way, you know?"

"No."

"It's power, you know? The power contained in matter. Matter has a monstrous power. I ... I feel to my touch that everything is in it and it's crawling ... And all this is being harnessed by an incredible effort. It is worth to shake from the inside - and bummm! - decay. Everything is an explosion. Any thought is an explosion in the brain. You give me your hand, and I feel something exploding in you. I have such a fine touch, brother. And hearing. Everything is noisy like soda in the water. These are all tiny explosions… Oh, how my head buzzes! Ta-ta-tata - like a machine gun."

"All right," said Tomacz. "Now take aspirin."

"Good. Blows ... explosive aspirin. Perchlorinated acetylsalicylic acid. Nonsense. But I, you know, discovered exothermic explosives. Actually, any body is an explosive. Water ... water is an explosive. The Earth ... and the air are also explosives. The feather, the fluff in the featherbed is explosive. Well, as long as it has only theoretical value. And I discovered atomic explosions. I … I invented an alpha explosion. Everything brrrreak … breaks up into positive particles. Thermochemistry does not exist. De… destruction. Destructive chemistry, that's what. This is a grandiose thing, Tomasz, from a purely scientific point of view. I have such tables at home ... Oh, if I had any equipment! But I have only eyes ... and hands ... "

5 points:

Krakatit, an explosive invented by Prokop possesses an immense explosive power: just one gram of this material was sufficient to destroy a large building. The detailed description of this compound is missing, but it seems to be some substance prepared by chemical means, and it is composed of argon, lead and some other elements. Is it possible to prepare a chemical explosive that fits Čapek's description, and how do you estimate the upper limit of the explosive energy a chemical explosive can produce?

Hint:

The total amount of energy that evolved during a chemical reaction (including explosions) is the difference between the energy of all chemical bonds that break and all chemical bonds that form.

Answer:

From the chemical point of view, explosion is just an exothermic reaction, and, in that sense, there is no difference between explosion and, for example, combustion. That means the upper limit of energy evolved during a chemical explosion is the energy of the most exothermic chemical reaction. As an example of a highly exothermic reaction, let's take combustion of magnesium in fluorine. Fluorine is the most active oxidizer, and magnesium is among the most active metals (the best fuel). The heat of formation of magnesium fluoride (1124.2 kJ/mol, or 1124.2/(24+18+18) = 19 kJ/g) is among the highest, so it is reasonable to expect no chemical reaction exists that can produce much more energy (per gram) than combustion of magnesium in fluorine. Let's assume the high estimate is 3 times more than the heat of combustion of magnesium in fluorine, or. 60 kJ/g. That means explosion of 1 g of the most powerful explosive can produce energy sufficient to lift just a 60 kg weight per 1 meter above the ground. Not impressive. Obviously, this energy is not sufficient to demolish even a small building.
Than means it is impossible to create a chemical substance whose explosive power is comparable with that of *Krakatit.*

10 points:

Carefully read the above conversation between Prokop and Tomasz and tell if you see anything wrong or inaccurate in what Prokop says? Namely,
- which Propkop's statements are correct, and which are wrong?
- which substances mentioned by Prokop can be prepared in a chemistry lab?
- is there any reason to expect these substances are explosive, or Prokop's intuition was wrong?
- explain your answer.

Hint:

Explosions are redox reactions, which means some atoms in the explosive molecule are being reduced, and other atoms are being oxidized (these atoms may belong to the same molecule, if the explosive is a pure compound, or to different molecules, if the explosive is a mixture). During reduction, oxidation state of an atom decreases, whereas during oxidation it increases. Some substance can be explosive when at least one electronegative atom in it has a very high oxidation state, and at least one atom has a low oxidation state.

Answer:

An explosion is a spontaneous transition of a substance, or a mixture of substances, from a higher energy state to a lower energy state. Simply speaking, it is a form of a combustion reaction, when both an oxidizer and a fuel are components of the explosive. For example, gunpowder contains saltpeter (potassium nitrate), which serves as a source of oxygen, and sulfur and charcoal, which act as a fuel.

How can we tell if some material can serve as a fuel or as an oxidizer? The best way to answer this question is to look at the oxidation state of each atom: if all atoms are in their “comfortable” oxidation state, such a substance is definitely not explosive. How can we tell if atoms feel “comfortable” is a substance? We can judge about that based on the way they are connected to each other. All elements can be characterized by the parameter called *electronegativity.* It means the ability of an atom to pull electrons. When two atoms, **A** and **B** are connected with a bond, and **A** is more electronegative than **B**, the common electron pair that forms the bond is displaced towards **A**. The most common elements can be arranged according to their electronegativity in the following series:

$$\text{Most metals} < H < P < C < S < I < Br < N < Cl < O < F$$

What is important and relevant to our story, ***the greater a difference in electronegativity between an atom A and atom B, the more stable is the bond between them****.* That means a reaction between hydrogen and chlorine (an H-H bond and an Cl-Cl bond break in this reaction, and two H-Cl bonds form) leads to a formation of two more stable bonds instead of two less stable ones:

$$H_2 + Cl_2 \rightarrow 2\ HCl$$

“More stable bond formation” means transition to the lower energy state, which means the excess of energy evolves. Indeed, a mixture of hydrogen and chlorine has explodes upon heating or when irradiated with a bright light.

In this process, hydrogen (less electronegative element) serves as a fuel, whereas chlorine is an oxidizer.

That observation explains us how can we recognize potentially explosive compounds: if a significant part of atoms with high electronegatvity (O, N, Cl, F, etc) are connected to other electronegative atoms, whereas there is an opportunity for them to re-connect in another way, and to form chemical bonds with less electronegative atoms, such a compound (or a mixture) is potentially explosive.

In addition to that, the molecules where two or more strongly electronegative atoms are connected to each other are potentially explosive too.

With this knowledge in mind, let’s analyze what Prokop was saying:

“**Explosive dextrin**”: Dextrins are just rings composed of several sugar (glucose) molecules. They cannot be more explosive than glucose itself. That means Prokop was wrong. However, he could use some jargon, so “explosive dextrin” could mean some explosive derivative of dextrin. Can explosive derivatives of dextrin be prepared? Yes. It can be done by nitration. By adding nitro groups (the groups where electronegative nitrogen is connected to electronegative oxygens) we add an oxidizer to the molecule that already has a fuel (sugar molecules). That means, yes, Prokop was right, explosive *derivatives* of dextrin can be prepared.
“...cerium nitrate - strong, a bastard” It is not clear if Prokop meant cerium (III) nitrate or cerium (IV) nitrate, but both of them are hardly explosive: they contain “an oxidizer” (a nitrate part), but no “fuel”. Prokop was wrong.

“**Chlorine, chlorine…”** Chlorine is a good oxidizer, but without a fuel it cannot be explosive. Prokop was wrong.
“**Tetraphase of nitrogen chloride**”: Prokop probably meant “nitrogen trichloride”. Yes this compound is explosive, because it contains electronegative nitrogen connected to three electronegative chlorine atoms.
“explosive aspirin. Perchlorinated acetylsalicylic acid. Nonsense.” Prokop means the aspirin derivative where all hydrogen atoms are replaced with chlorins. This compound does exist, but there is no reason to expect it is explosive: electronegative atoms of chlorine are connected to carbon atoms, which have low electronegativity, so every atom “feel comfortable” there. Probably, Prokop realized than when he said: “nonsense”.
“Actually, any body is an explosive. Water ... water is an explosive” Wrong. Water is not explosive, because highly electronegative oxygen is connected to two hydrogens. We know that hydrogen has low electronegativity, so all atoms in water “feel comfortable”, and they do not need to rearrange. With regard to “any body is explosive”, it is a kind of a logical fallacy: when some body or some substance explodes, the products of such explosion is another substance with lower energy (higher stability). Obviously, that means that the products of explosion (as well as combustion products) cannot be explosive, that means there are some bodies and some substances that are not explosive.
“**I discovered atomic explosions.**” We know atomic explosions (for example, uranium fission) are possible, although during the times *Krakatit* was written they had not been discovered yet, but, yes, Prokop is speaking about the phenomenon that is potentially possible.
“ **I … I invented an alpha explosion. Everything brrrreak … breaks up into positive particles.**” “Alpha-explosion is something odd. Matter cannot spontaneously decompose on alpha-particles. In general, matter cannot break up on positive particles, simply because electric charge cannot appear from nothing: when positive particles form, the same amount of negative particles are supposed to form too.

BIOLOGY

5 points:

As alternative to using chemical control for agricultural pests, a biological control could be used. Biological control is an organism which would dramatically reduce population of the pest. It could be a predator that attacks the pest or a parasite that uses the pest's organism as a host. Imagine that you are a minister of agriculture, and you have a problem: the main agricultural plant in your country is being massively attacked of some beetle. Two different research groups proposed their solutions to this problem: one group is working on a novel chemical pesticide that efficiently kills the beetle, whereas another group proposes to introduce a new species of a wasp that was recently identified in South America: this wasp lays eggs on the beetle, so wasp's larvae develop inside the beetle's body and kill it before the beetle produces its own offsprings. You have to decide which project should be funded (you can fund only one project). Please, explain which factors have to be taken into account for making an optimal decision. In which case the first project should be selected, and which considerations can make the second project more competitive?

Answer:

Two universal criteria are efficiency and side effects.

Efficiency of chemical pesticides can be limited, for example, by the rate of resistance development. The group that proposes a chemical pesticide is supposed to show data demonstrating that there is a reason to expect the pest will not develop resistance to this particular pesticide quickly.

Efficiency of biological treatment is limited by the many factors. If the beetle is the only species the wasp can prey on, the wasps can hardly eradicate the beetle completely, because when the beetle population will go down, the wasps population will start to decrease too, so both populations will start to oscillate (as described by Volterra-Lotka equation) around some average level. The group that proposes an introduction of wasps is supposed to demonstrate that the method they are advocating will allow keeping beetle's population below the acceptable level.

Side effects. The side effects of chemical pesticides are obvious: it is necessary to demonstrate the pesticide will not be harmful for humans, animals, agricultural plants, and that the negative impact of the proposed substances on environment will be below acceptable limits.

Regarding wasps, it is always necessary to remember that introduction of new species is always dangerous, because it it hard to predict its full impact on the new ecosystem, and it much easier to introduce a new species than to eradicate it from an ecosystem when something goes wrong.

10 points:

We know that mutation rate during a replication of many viruses (especially, HIV) is much greater that the rate of mutation in host cells (for example, human cells). This, as well as a rapid (exponential) growth of the population of viruses in an infected organism allows viruses to quickly develop resistance towards many antiviral drugs. As a result, first generation anti-HIV drugs (for example, zidovudine), which were quite efficient 20 years ago, are currently almost inefficient, and next generation drugs are needed to suppress HIV.

We also know that cancer cells have increased mutation rate too, and they also grow exponentially, so it is not a surprise that the drugs that efficiently suppress tumor's growth at the early stage of cancer development may become inefficient at later stage of the disease. However, in contrast to AIDS, anti-cancer drugs do not lose their efficiency in new patients, so the drug that efficiently suppressed cancer growth, e.g. 20 years ago, works with the same efficiency for new patients.

Can you explain why many antiviral drugs lose their efficiency in several years (or decades) after they became popular, but anticancer drugs do not?

Answer:

When a virus evolves in a host organism, every new generation of viruses inherits the traits that facilitate survival. When new viral particles leave a body of an infected human, their genome contains all information about all beneficial traits they developed, including drug resistance. That means drug resistance will be gradually increasing when a virus is propagating in a population of humans that are being treated with the same drug.

Cancer cells, like viruses, also develop resistance towards drugs, however, all of them stays in human organism, and they cannot be transmitted from one person to another (there are, possibly, some exceptions to this rule, but they are extremely rare). The reason is simple: cancer cells are just a specific type of human cells, so they can exist only in their own organism. The transfer of cancer from one organism to another is almost impossible: cancer cells will be immediately recognised as foreign cells by the immune system of a new organism, and will be killed immediately. Since cancer tumors cannot be transmitted from one organism to another, all traits that facilitate tumor’s survival also cannot be transmitted to new tumors. That is why the drug that is gradually losing efficiency in some patient at later stage of tumor’s development is still active in new patients.

COMPUTER SCIENCE

- You can write and compile your code here: http://www.tutorialspoint.com/codingground.htm
- Your program should be written in Java or Python
- No GUI should be used in your program: eg., easygui in Python. All problems in POM require only text input and output. GUI usage complicates solution validation, for which we are also using *codingground* site. Solutions with GUI will have points deducted or won’t receive any points at all.
- Please make sure that the code compiles and runs on http://www.tutorialspoint.com/codingground.htm before submitting it.
- Any input data specified in the problem should be supplied as user input, not hard-coded into the text of the program.

- Submit the problem in a plain text file, such as .txt, .dat, etc.
  No .pdf, .doc, .docx, etc!

5 points:

You know that numbers can be expressed in different base number systems. Every day we operate with numbers in base 10, while computers like base 2 and base 16. But what if we are given a number and not told what base is it in. For example, 13. We understand what it is in base 10. In base 8 it is same as 11 in base 10. However, it cannot be a number in base 2!

Your program should enter a number from input. The number may contain digits 0-9 as well as a-f. For this number your program should calculate what is the smallest base this number could be written in, and then transform and print its value in base 10. For our example above, given 13 as an input, the smallest base would be 4, and 13 base 4 is 7 base 10.

Solution:

Python:

```
import functools

# we'll keep the numbers as strings

num = input("enter a number: ").upper()
print("the number is %s" % num)
k = len(num)

# check if the input is valid
for i in range(k):
  if not (num[i]>='0' and num[i]<='9' or num[i]>='A' and num[i]<='F'):
    raise ValueError("invalid digit '%s'; use 0-9, A-F" % num[i])

# assumes ch is valid
def char2digit(ch):
  try:
    digit = int(ch)
  except ValueError:
    digit = int(ord(ch) - ord('A')) + 10
  return digit

# the smallest base is the largest digit + 1
base_char = chr(functools.reduce(lambda a,b: a if a >= ord(b) else ord(b), num, 0))
base = char2digit(base_char) + 1
print("the smallest base is %d" % base)

# convert num to base 10
# e.g. 123 base 4 is 1*4^2 + 2*4^1 + 3*4^0
num10 = 0
for i in range(k):
  num10 += char2digit(num[k-i-1])*pow(base, i)
```

```
print("the number base 10 is %s" % num10)

# to verify let's use python's function
x = int(num, base)
assert(num10 == x)

print("end.")
""" =>
the number is A12F
the smallest base is 16
the number base 10 is 41263
"""
```

Java:

```
import java.io.BufferedReader;
import java.io.InputStreamReader;

public class NumberBase {
  // assumes ch is valid
  private static int char2digit(char ch) {
    int digit;
    if(Character.isDigit(ch))
      digit = Character.getNumericValue(ch);
    else
      digit = (int)ch - (int)'A' + 10;
    return digit;
  }

  public static void main(String[] args) throws Exception {
    // we'll keep the numbers as strings

    System.out.print("enter a number: ");
    BufferedReader br = new BufferedReader(new InputStreamReader(System.in));
    String num = br.readLine().trim().toUpperCase();
    System.out.printf("the number is %s\n", num);
    int k = num.length();

    // check if the input is valid
    for(int i=0; i<k; i++) {
      char ch = num.charAt(i);
      if(!(ch >= '0' && ch <= '9' || ch >= 'A' && ch <= 'F'))
          throw new IllegalArgumentException(String.format("invalid digit '%c'; use 0-9, A-F",
ch));
    }

    // the smallest base is the largest digit + 1
    char base_char = (char)num.chars().reduce(0, (a,b) -> a >= b ? a : b);
    int base = char2digit(base_char) + 1;
    System.out.printf("the smallest base is %d\n", base);

    // convert num to base 10
    // e.g. 123 base 4 is 1*4^2 + 2*4^1 + 3*4^0
    int num10 = 0;
    for(int i=0; i<k; i++)
      num10 += char2digit(num.charAt(k-i-1)) * Math.pow(base, i);
    System.out.printf("the number base 10 is %d\n", num10);
    // to verify let's use java's function
    int x = Integer.parseInt(num, base);
    if(num10 != x)
      throw new Exception(String.format("%d != %d", num10, x));

    System.out.println("end.");
  }
}
/* =>
the number is A12F
the smallest base is 16
the number base 10 is 41263
*/
```

10 points:

You may know a game called Reversi (https://en.wikipedia.org/wiki/Reversi). In this game, played on a 8x8 board, players take turns placing disks on the board. Each disk is white on one side and black on the other. For a player playing white a valid move is to place a disk white side up on an empty square so that there is another white disk present in a straight vertical, horizontal or diagonal line, following a number of black disks. This would cause all the "surrounded" black disks flipped (or reversed - hence, the name Reversi) to their white side.

In modern Reversi, the initial position (let's say, X is a black disk, and O is a white disk) is:

```
--------
--------
--------
---OX---
---XO---
--------
--------
--------
```

In this position valid moves for X are (denoted by *):

```
--------
--------
---*----
--*OX---
---XO*--
----*---
--------
--------
```

Your program should enter some Reversi position from input, figure out whose move it is (let's presume that X always starts the game), and print the board marking all possible next moves, the way we did above.

Solution:

Python:

```
# board = [['-','-','-','-','-','-','-','-'],
#          ['-','-','-','-','-','-','-','-'],
#          ['-','-','-','-','-','-','-','-'],
#          ['-','-','-','O','X','-','-','-'],
#          ['-','-','-','X','O','-','-','-'],
#          ['-','-','-','-','-','X','-','-'],
#          ['-','-','-','-','-','-','-','-'],
#          ['-','-','-','-','-','-','-','-']]
# m = len(board)
# n = len(board[0])

m = 8
n = 8
board = [[' ' for j in range(n)] for i in range(m)] # caveat: this references the same object:
[[' ']*n]*m

# input
for i in range(m):
  line = input("enter the row %d of %d, e.g. ---OX--- " % (i+1, m)).strip().upper()
  if len(line) != n:
    raise ValueError("line must be %d characters" % n)
  for j in range(n):
    ch = line[j]
    if ch=='X' or ch=='O' or ch=='-':
      board[i][j] = ch
    else:
      raise ValueError("invalid character '%c'" % line[j])

print("initial board:")
print('\n'.join([''.join(["%c" % item for item in row]) for row in board]))

def checkLeft(ch, iStart, jStart):
  i = iStart
  j = jStart
  while j>=0 and board[i][j]==ch:
    j -= 1

  if 0 <= i < m and 0 <= j < n and j < jStart:
    board[i][j] = '*'

def checkRight(ch, iStart, jStart):
  i = iStart
  j = jStart
  while j<n and board[i][j]==ch:
    j += 1

  if 0 <= i < m and 0 <= j < n and j > jStart:
    board[i][j] = '*'

def checkUp(ch, iStart, jStart):
  i = iStart
  j = jStart
  while i>=0 and board[i][j]==ch:
    i -= 1

  if 0 <= i < m and 0 <= j < n and i < iStart:
    board[i][j] = '*'

def checkDown(ch, iStart, jStart):
  i = iStart
  j = jStart
  while i<m and board[i][j]==ch:
    i += 1

  if 0 <= i < m and 0 <= j < n and i > iStart:
    board[i][j] = '*'

def checkUpLeft(ch, iStart, jStart):
  i = iStart
  j = jStart
  while i>=0 and j>=0 and board[i][j]==ch:
    i -= 1
    j -= 1

  if 0 <= i < m and 0 <= j < n and j < jStart:
    board[i][j] = '*'

def checkUpRight(ch, iStart, jStart):
  i = iStart
  j = jStart
  while i>=0 and j<n and board[i][j]==ch:
    i -= 1
    j += 1

  if 0 <= i < m and 0 <= j < n and j > jStart:
    board[i][j] = '*'

def checkDownLeft(ch, iStart, jStart):
  i = iStart
  j = jStart
  while i<m and j>=0 and board[i][j]==ch:
    i += 1
    j -= 1

  if 0 <= i < m and 0 <= j < n and i > iStart:
    board[i][j] = '*'

def checkDownRight(ch, iStart, jStart):
  i = iStart
  j = jStart
  while i<m and j<n and board[i][j]==ch:
    i += 1
    j += 1

  if 0 <= i < m and 0 <= j < n and i > iStart:
    board[i][j] = '*'

# figure out whose move it is (X always starts the game)
# if # of pieces on the board even - it's X's move, if odd - O's
X_count = sum([board[i].count('X') for i in range(m)])
O_count = sum([board[i].count('O') for i in range(m)])
count = X_count + O_count
X_to_move = count % 2 == 0

ch = 'X' if X_to_move else 'O'
c = 'O' if X_to_move else 'X'
# for each 'X'
for i in range(m):
  for j in range(n):
    if board[i][j] == ch:
      checkLeft(c, i, j-1)
      checkRight(c, i, j+1)
      checkUp(c, i-1, j)
      checkDown(c, i+1, j)
      checkUpLeft(c, i-1, j-1)
      checkUpRight(c, i-1, j+1)
      checkDownLeft(c, i+1, j-1)
      checkDownRight(c, i+1, j+1)

print("next possible moves for '%c':" % ch)
print('\n'.join([''.join(["%c" % item for item in row]) for row in board]))

print("end.")
""" =>
next possible moves for 'O':
next possible moves for 'O':
--------
--------
----*---
---OX*--
--*XO---
---*-X--
------*-
--------
"""
```

Java:

```
import java.io.BufferedReader;
import java.io.IOException;
import java.io.InputStreamReader;

class Coordinate {
  boolean valid;
  int i, j;
  Coordinate(boolean valid, int i, int j) {
    this.valid = valid;
    this.i = i;
    this.j = j;
  }
}

public class Reversi {
  //char[][] board = {{'-','-','-','-','-','-','-','-'},
  //                  {'-','-','-','-','-','-','-','-'},
  //                  {'-','-','-','-','-','-','-','-'},
  //                  {'-','-','-','O','X','-','-','-'},
  //                  {'-','-','-','X','O','-','-','-'},
  //                  {'-','-','-','-','-','X','-','-'},
  //                  {'-','-','-','-','-','-','-','-'},
  //                  {'-','-','-','-','-','-','-','-'}};
  //int m = board.length;
  //int n = board[0].length;
  int m = 8;
  int n = 8;
  char[][] board = new char[m][n];

  void print(String str) {
    System.out.println(str);
    for(int i=0; i<m; i++) {
      for(int j=0; j<n; j++) {
        System.out.print(board[i][j]);
      }
      System.out.println();
    }
  }

  void solve() throws IOException {
    // input
    BufferedReader br = new BufferedReader(new InputStreamReader(System.in));
    for(int i=0; i<m; i++) {
      System.out.printf("enter the row %d of %d, e.g. ---OX--- ", i+1, m);
      String line = br.readLine().trim().toUpperCase();
      if(line.length() != n)
        throw new IllegalArgumentException(String.format("line must be %d characters", n));
      for(int j=0; j<n; j++) {
        char ch = line.charAt(j);
        if(ch=='X' || ch=='O' || ch=='-')
          board[i][j] = ch;
        else
          throw new IllegalArgumentException(String.format("invalid character '%c'", ch));
      }
    }
    print("initial board:");

    // figure out whose move it is (X always starts the game)
    // if # of pieces on the board even - it's X's move, if odd - O's
    int countO = 0;
    int countX = 0;
    for(int i=0; i<m; i++) {
      for(int j=0; j<n; j++) {
        if(board[i][j] == 'X')
          countX++;
        else if(board[i][j] == 'O')
          countO++;
      }
    }
    int count = countX + countO;
    boolean X_to_move = count % 2 == 0;

    char ch = X_to_move ? 'X' : 'O';
    char c = X_to_move ? 'O' : 'X';
    // for each 'X'
    for(int i=0; i<m; i++) {
      for(int j=0; j<n; j++) {
        if(board[i][j] == ch) {
          Coordinate coor = checkLeft(c, i, j-1);
          if(coor.valid)
            board[coor.i][coor.j] = '*';
          coor = checkRight(c, i, j+1);
          if(coor.valid)
            board[coor.i][coor.j] = '*';
          coor = checkUp(c, i-1, j);
          if(coor.valid)
            board[coor.i][coor.j] = '*';
          coor = checkDown(c, i+1, j);
          if(coor.valid)
            board[coor.i][coor.j] = '*';

           coor = checkUpLeft(c, i-1, j-1);
          if(coor.valid)
            board[coor.i][coor.j] = '*';
          coor = checkUpRight(c, i-1, j+1);
          if(coor.valid)
            board[coor.i][coor.j] = '*';
          coor = checkDownLeft(c, i+1, j-1);
          if(coor.valid)
            board[coor.i][coor.j] = '*';
          coor = checkDownRight(c, i+1, j+1);
          if(coor.valid)
            board[coor.i][coor.j] = '*';
        }
      }
    }

    print(String.format("next possible moves for '%c':", ch));
  }

  Coordinate checkLeft(char ch, int iStart, int jStart) {
    int i = iStart;
    int j = jStart;
    while(j>=0 && board[i][j]==ch)
      j--;

    boolean valid = false;
    if(i>=0 && i<m && j>=0 && j<n && j<jStart)
      valid = true;
    return new Coordinate(valid, i, j);
  }

  Coordinate checkRight(char ch, int iStart, int jStart) {
    int i = iStart;
    int j = jStart;
    while(j<n && board[i][j]==ch)
      j++;

    boolean valid = false;
    if(i>=0 && i<m && j>=0 && j<n && j>jStart)
      valid = true;
    return new Coordinate(valid, i, j);
  }

  Coordinate checkUp(char ch, int iStart, int jStart) {
    int i = iStart;
    int j = jStart;
    while(i>=0 && board[i][j]==ch)
      i--;

    boolean valid = false;
    if(i>=0 && i<m && j>=0 && j<n && i<iStart)
      valid = true;
    return new Coordinate(valid, i, j);
  }

  Coordinate checkDown(char ch, int iStart, int jStart) {
    int i = iStart;
    int j = jStart;
    while(i<m && board[i][j]==ch)
      i++;

    boolean valid = false;
    if(i>=0 && i<m && j>=0 && j<n && i>iStart)
      valid = true;
    return new Coordinate(valid, i, j);
  }

  Coordinate checkUpLeft(char ch, int iStart, int jStart) {
    int i = iStart;
    int j = jStart;
    while(i>=0 && j>=0 && board[i][j]==ch) {
      i--;
      j--;
    }

    boolean valid = false;
    if(i>=0 && i<m && j>=0 && j<n && j<jStart)
      valid = true;
    return new Coordinate(valid, i, j);
  }

  Coordinate checkUpRight(char ch, int iStart, int jStart) {
    int i = iStart;
    int j = jStart;
    while(i>=0 && j<n && board[i][j]==ch) {
      i--;
      j++;
    }

    boolean valid = false;
    if(i>=0 && i<m && j>=0 && j<n && j>jStart)
      valid = true;
    return new Coordinate(valid, i, j);
  }

  Coordinate checkDownLeft(char ch, int iStart, int jStart) {
    int i = iStart;
```

```
    int j = jStart;
    while(i<m && j>=0 && board[i][j]==ch) {
      i++;
      j--;
    }

    boolean valid = false;
    if(i>=0 && i<m && j>=0 && j<n && i>iStart)
      valid = true;
    return new Coordinate(valid, i, j);
  }

  Coordinate checkDownRight(char ch, int iStart, int jStart) {
    int i = iStart;
    int j = jStart;
    while(i<m && j<n && board[i][j]==ch) {
      i++;
      j++;
    }

    boolean valid = false;
    if(i>=0 && i<m && j>=0 && j<n && i>iStart)
      valid = true;
    return new Coordinate(valid, i, j);
  }

  public static void main(String[] args) throws Exception {
    Reversi reversi = new Reversi();
    reversi.solve();

    System.out.println("end.");
  }
}
/* =>
next possible moves for 'X':
--------
--------
---*----
--*OX---
---XO*--
----*---
--------
--------
*/
```