



The question book



Creative problem solving

Acknowledgements

- Patrons:** Sh. Ramesh Pokhriyal, 'Nishank', Hon'ble Minister of Human Resource Development, Government of India
- Sh. Sanjay Dhotre, Hon'ble Minister of State, Minister of Human Resource Development, Government of India
- Ms. Anita Karwal, Secretary, Department of School Education and Literacy, Ministry of Human Resource Development
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The question book

Every species on this earth faces problem, big or small and finds probable solution(s) for it through various ways as per their capabilities and limitations. Problem solving is a daily activity for most of us, whether we realize it or not. Whenever there is a gap between where you are now and where you want to be and you don't know how to cross that gap, you have a problem¹. For example, if you want to go to your friends place and there are three paths to take and you don't know how to find the best path to take, that is a problem and when you figure out the best path after looking into various aspects that's problem solving.

Learning and understanding the process of problem solving and recognizing patterns in problems is a lifelong activity and a skill that can be applied both in personal and professional lives. This is one of the most essential 21 st century skills for anyone to learn.

The question book in your hand will take you through a journey where you will find various kinds of problems and discussions on them to find the probable solutions after looking into pros and cons of various aspects of it. It will also give you an opportunity to identify the problems in your daily life for which you will find best solutions yourself.

- Ankit and Ankita

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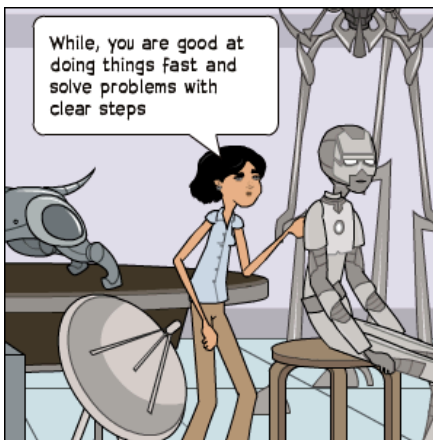
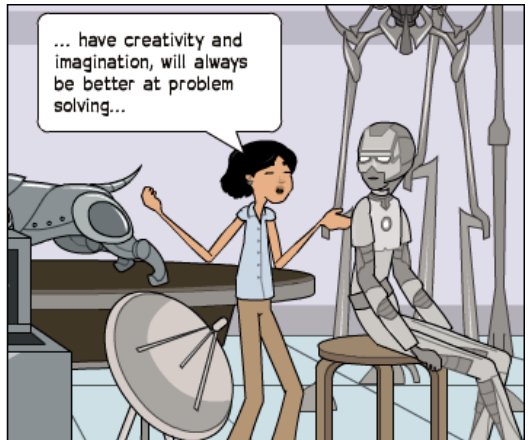
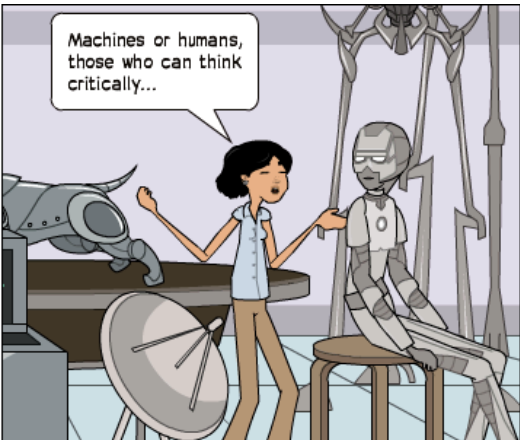
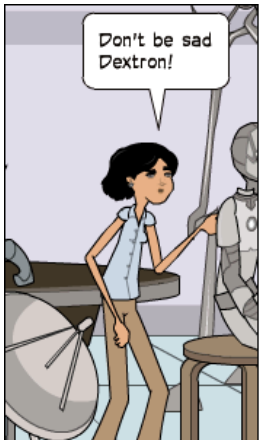
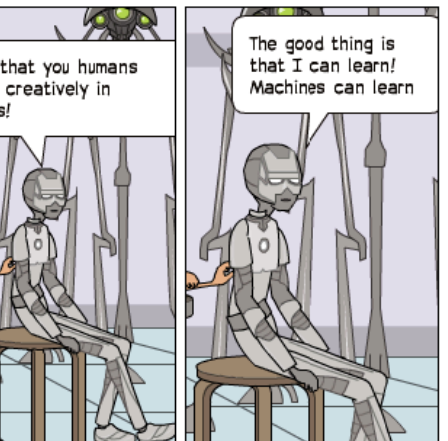
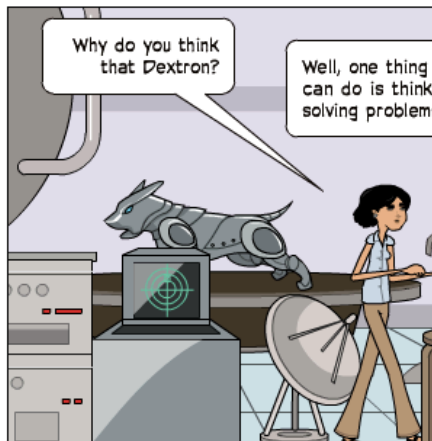
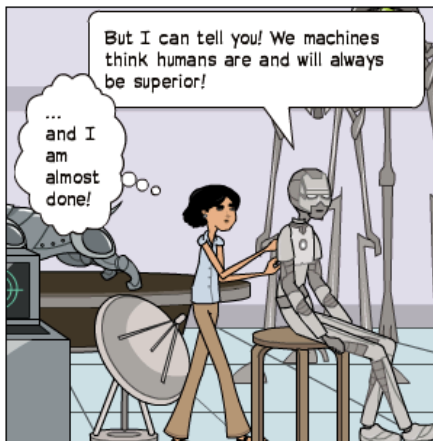
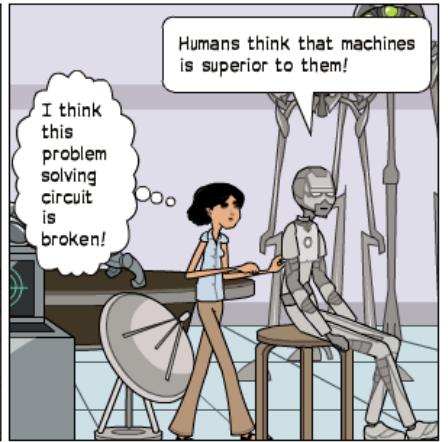
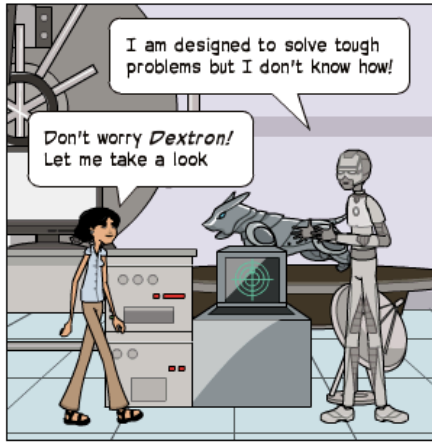
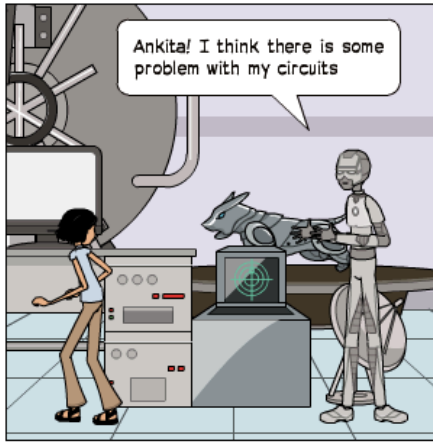
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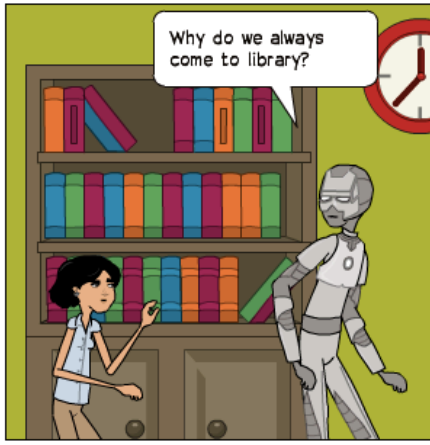
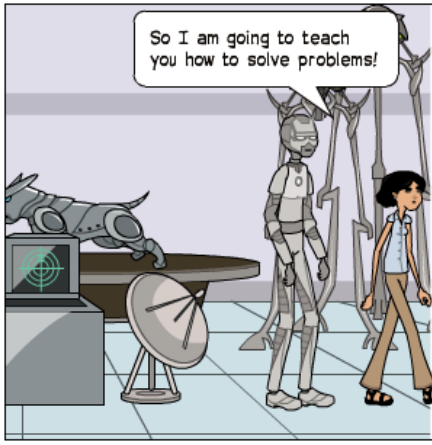
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The question book

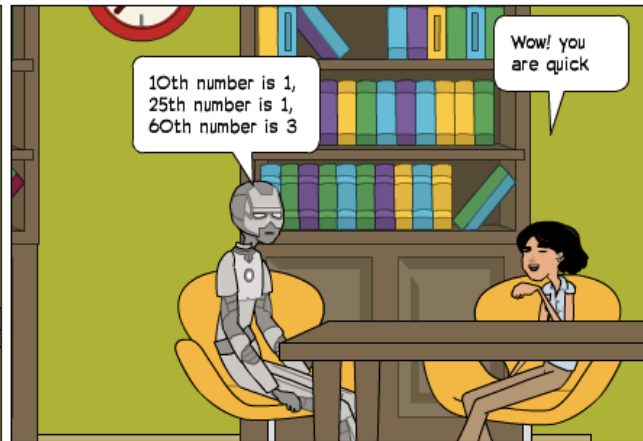
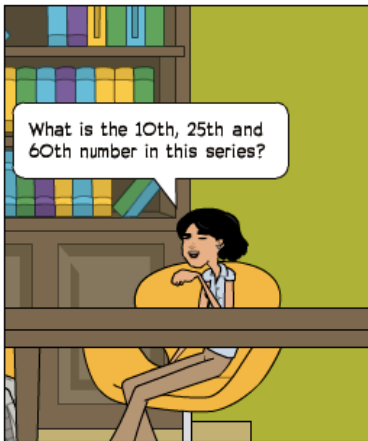
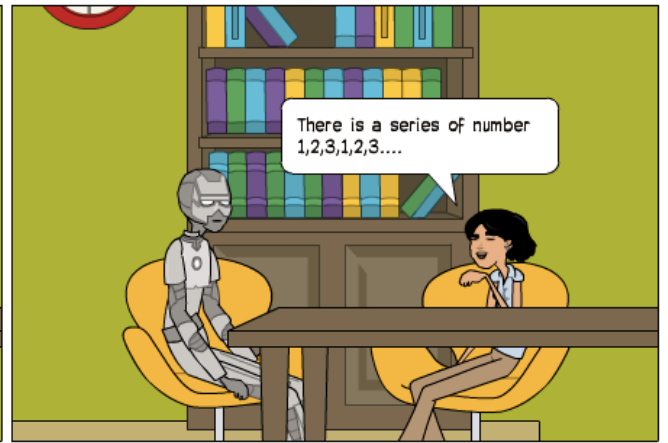






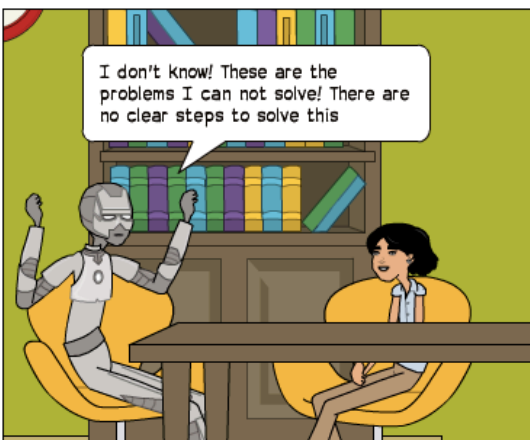
Step by Step





In a competition to make snowmen, the children made 60 snowmen. The heads of the snowmen followed a particular pattern shown on the diagram below. How do the heads of the 10th, the 25th and the 60th snowman look like?

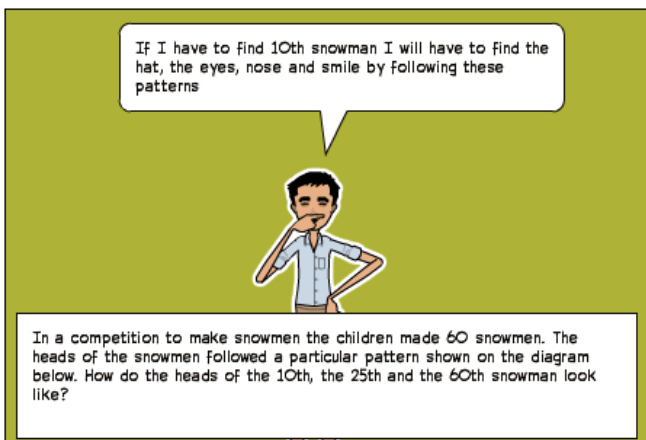
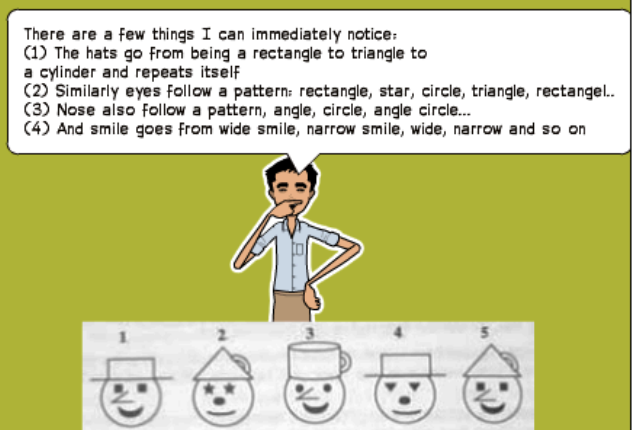
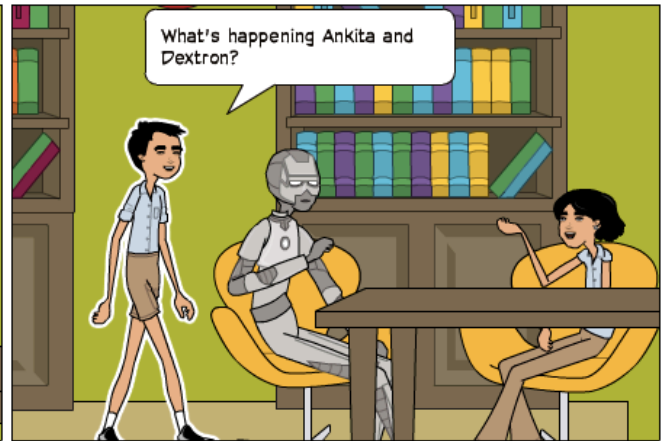
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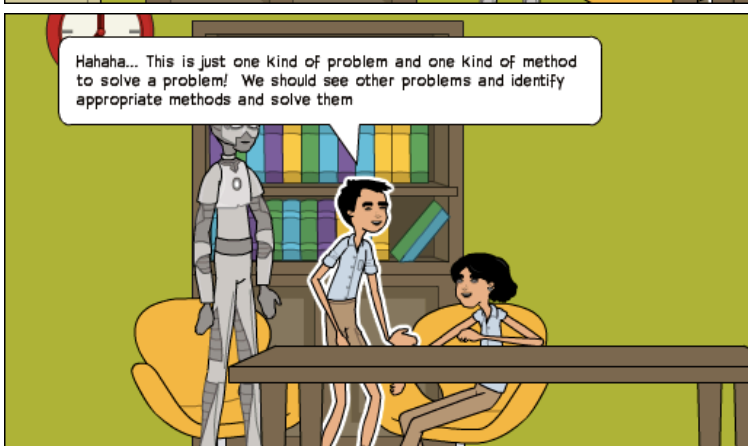
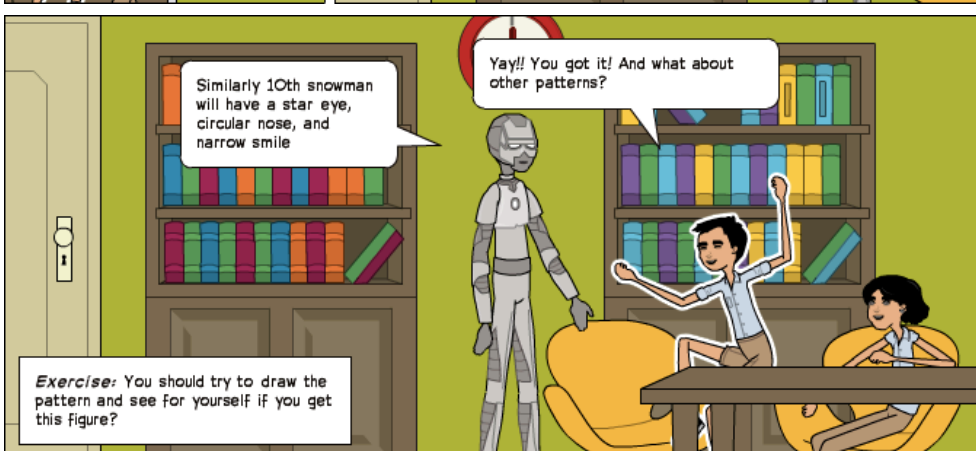
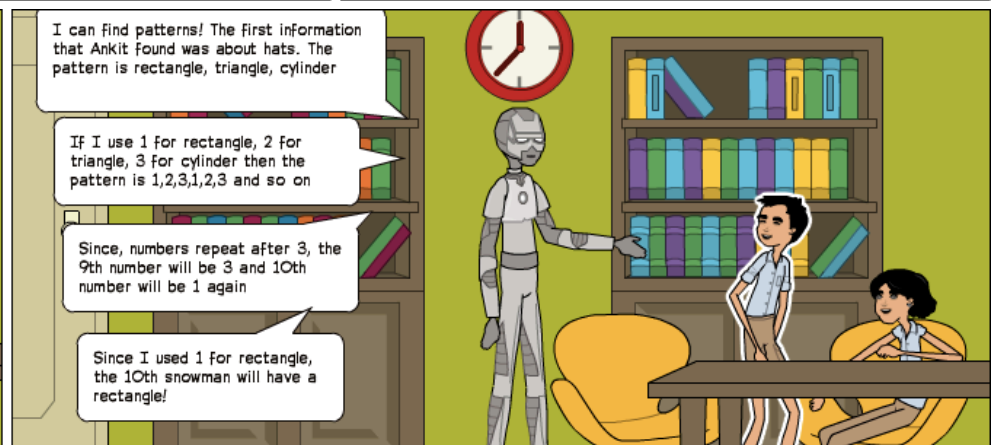
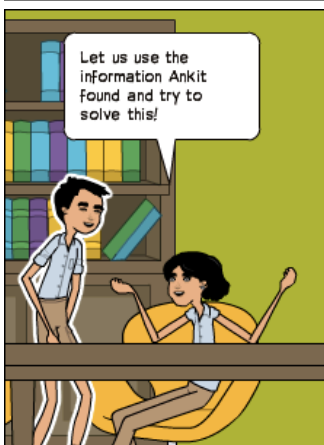
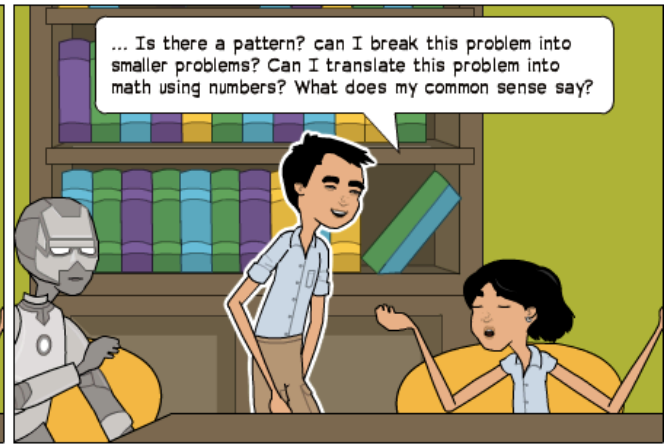


Step 1: identifying which pieces of data are relevant when faced with a mass of data, most of which is irrelevant

Step 2: combining pieces of information that may not appear to be related to give new information

Step 3: relating one set of information to another in a different form - this involves using experience: relating new problems to ones we have previously solved.





Polya's Problem Solving framework



George Pólya was a Hungarian mathematician. He made fundamental contributions to combinatorics, number theory, numerical analysis and probability theory. He is also noted for his work in heuristics and mathematics education.

(December 13, 1887 - July 9th, 1985)

First step

You have to understand the problem

Questions you should ask to yourself

What is the problem? What is the unknown in the problem? What is the data and facts that we already know? What is the condition?

Second step

Find the connection between data and the unknown

Have you seen it before or in a slightly different form? Do you know a related problem? Look at the unknown and try to think of a familiar problem having the same or similar unknown.

Third step

Carry out your plan

Carrying out a plan of the solution, check each step. Can you see clearly that the step is correct? Can you prove that it is correct?

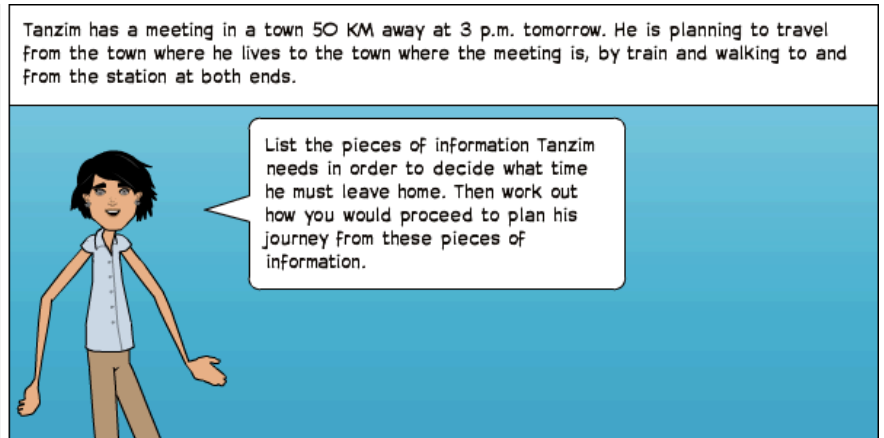
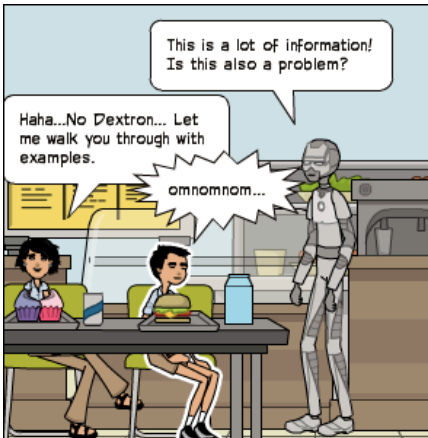
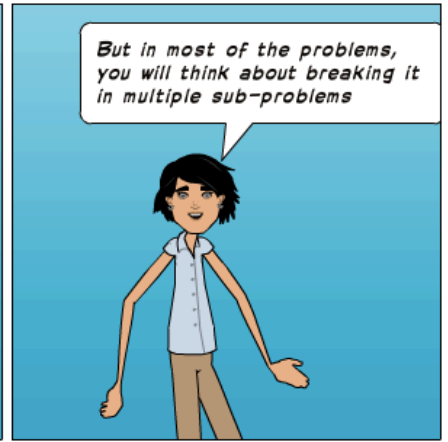
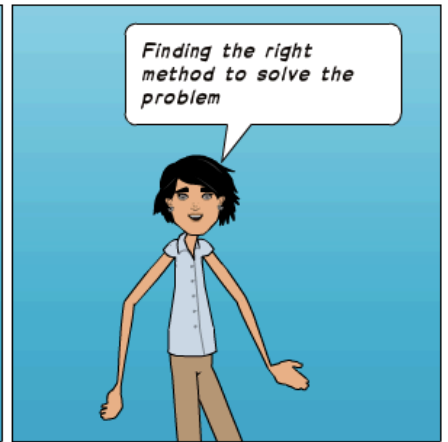
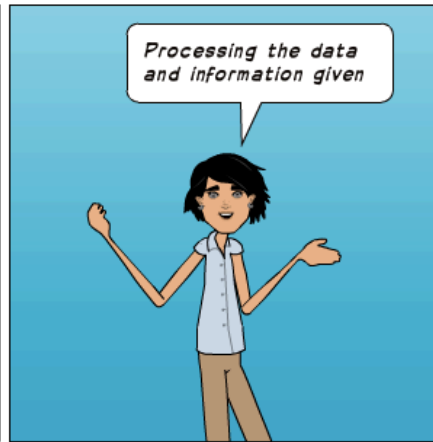
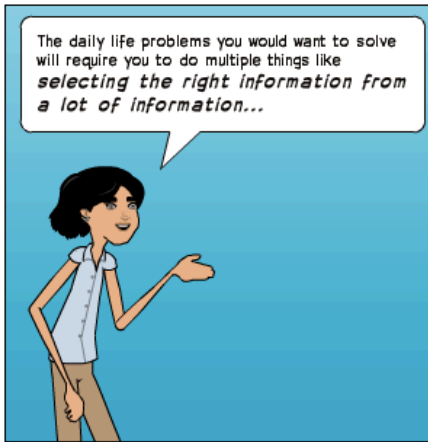
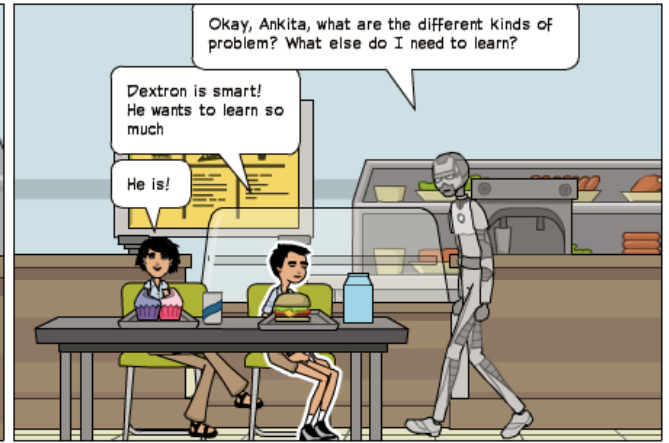
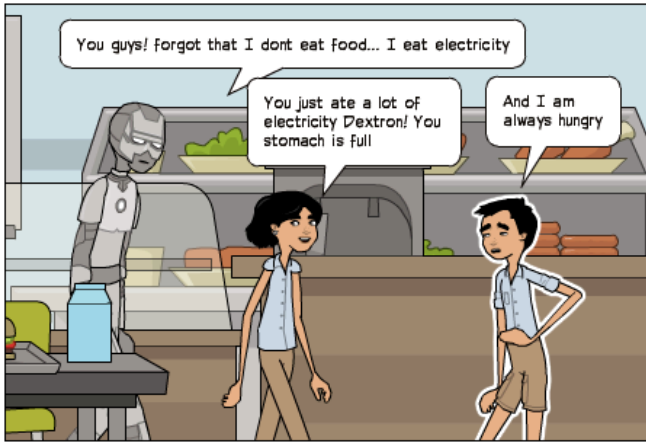
Fourth step

Examine the solution obtained

Can you check the result? Can you check the argument? Can you derive the results differently? Can you see the result, or method for some other problem?

I need this, I need this not

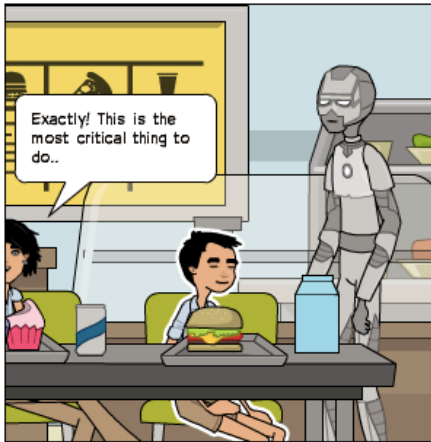




Tanzim needs to leave his house, walk to the station, buy train ticket, go to platform, wait for train and get in, sit inside till he reaches and then walk back



The pieces of information Tanzim needs are:
 1. Time taken to walk till station
 2. Time needed to get the ticket
 3. Time needed to walk to the platform.
 4. The train timetable
 5. The time taken to walk from the station to where the meeting is being held.



Exactly! This is the most critical thing to do..



Always find all the information you need to solve the problem and only then proceed



Now let's go one step ahead. Find the information and check the data

RHEA HAS BEEN STAYING IN A HOTEL ON A BUSINESS TRIP. WHEN SHE CHECKS OUT, THE HOTEL'S COMPUTER ISN'T WORKING, SO THE RECEPTIONIST MAKES A BILL BY HAND FROM THE RECEIPTS, TOTALING **RS. 3635**. RHEA THINKS SHE HAS BEEN OVERCHARGED, SO SHE CHECKS THE ITEMIZED BILL CAREFULLY.

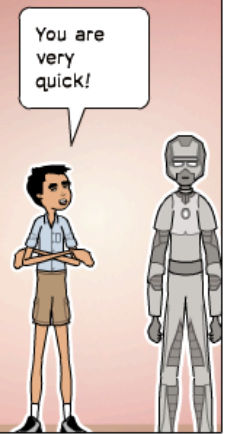
ROOM: 4 NIGHTS AT RS. 532.00 PER NIGHT
BREAKFAST: 4 AT RS. 70.00 EACH
DINNERS: 3 AT RS. 126.00 EACH
TELEPHONE: 10 UNITS AT RS 1 PER UNIT
RESTAURANT: VARIOUS DRINKS TOTALING RS. 161.00
LALINDRY: 3 DRESSES AT RS. 100.00 EACH

IT APPEARS THAT THE RECEPTIONIST MISCOUNTED ONE OF THE ITEMS WHEN ADDING UP THE TOTAL. WHICH ITEM HAS RHEA BEEN CHARGED TOO MUCH FOR?

Hmmm... Let's see the total according to the itemized bill is..

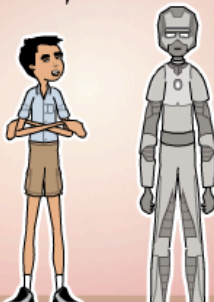
Rs 3257

- (1) $4 \times 532 = \text{RS } 2128$
- (2) $4 \times 70 = \text{RS } 280$
- (3) $3 \times 126 = \text{RS } 378$
- (4) $10 \times 1 = \text{RS } 10$
- (5) $\text{RS } 161$
- (6) $3 \times 100 = \text{RS } 300$

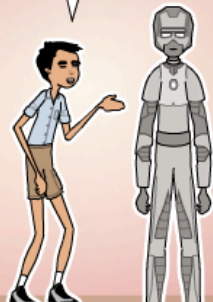


You are very quick!

Anyways! This means that $\text{Rs } 3635 - \text{Rs } 3257 = \text{Rs } 378$



This means, that she has been charged for an extra dinner

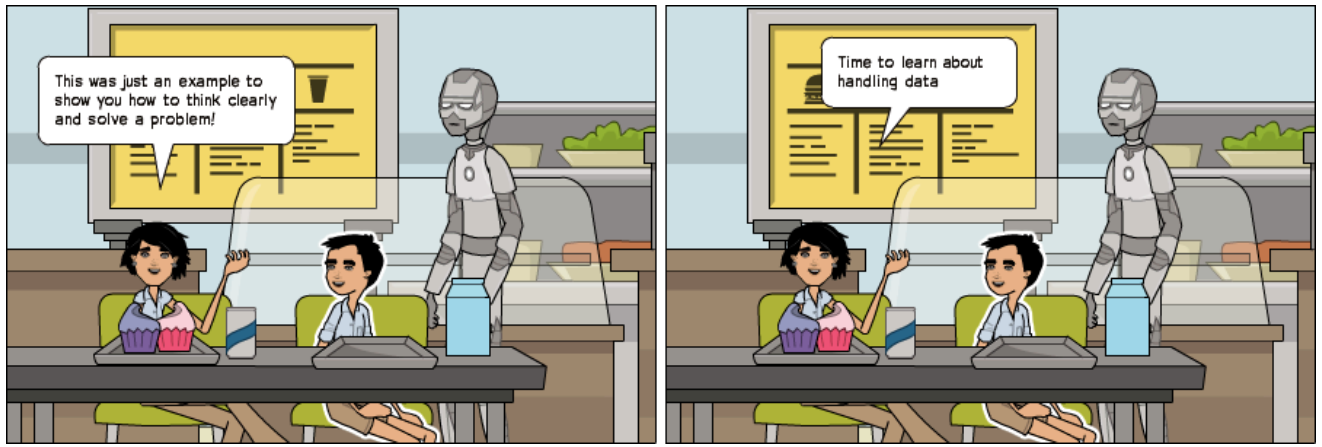


Because nothing else could come exactly to Rs 18



Yes! It seems you are right





Practice Problem

Problem 1

Rajesh is cooking a meal for some friends.

This will involve roasting corns (makka), which will take 2 hours' cooking time plus 15 minutes resting on removal from the oven. The oven takes 15 minutes to warm up. He will also cook some rice (30 minutes' soaking plus 15 minutes' cooking), cabbage (5 minutes to prepare and 5 minutes to cook) and a tomato sauce (10 minutes to prepare and 15 minutes to cook).

What should be the timing of each step of cooking the meal if the friends are to eat at 7 p.m.?

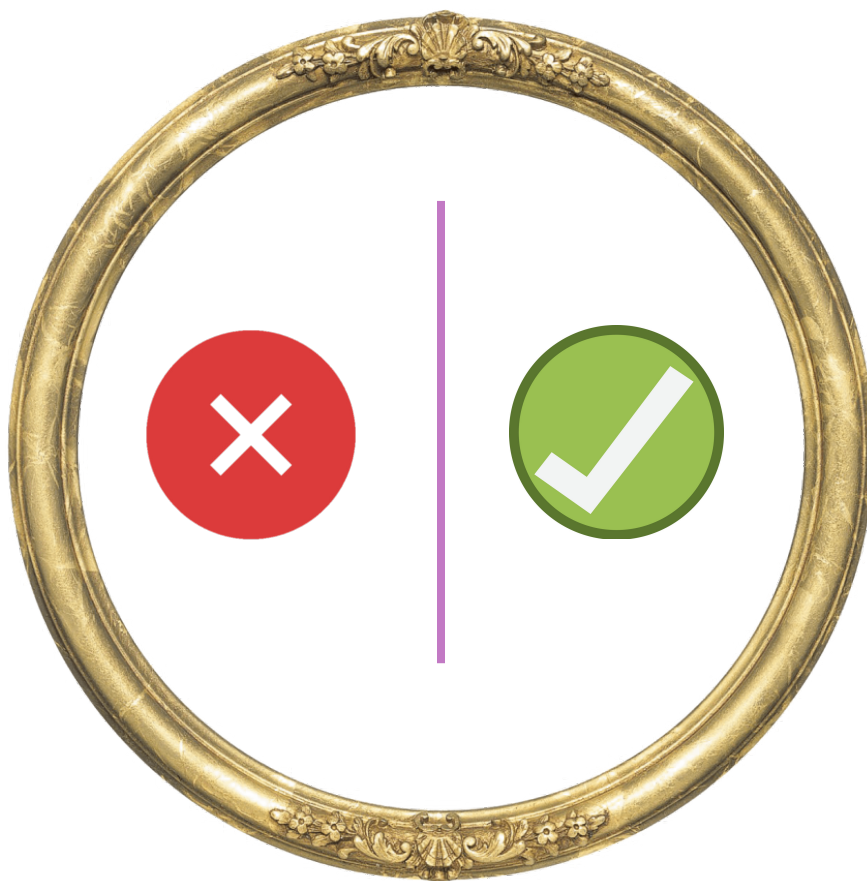
Problem 2

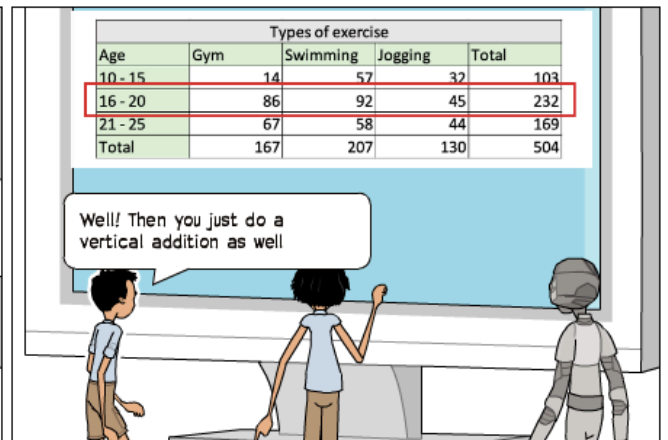
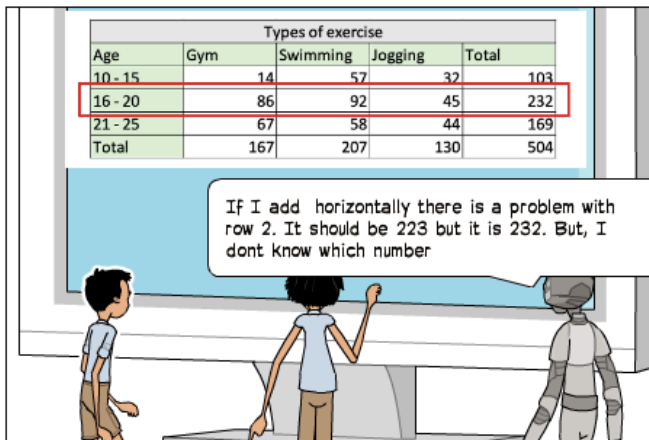
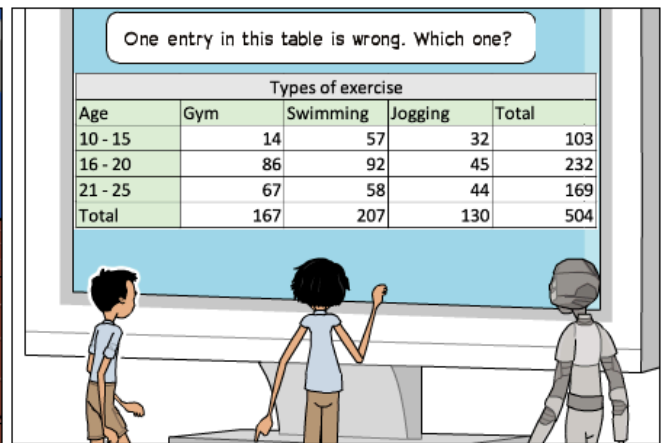
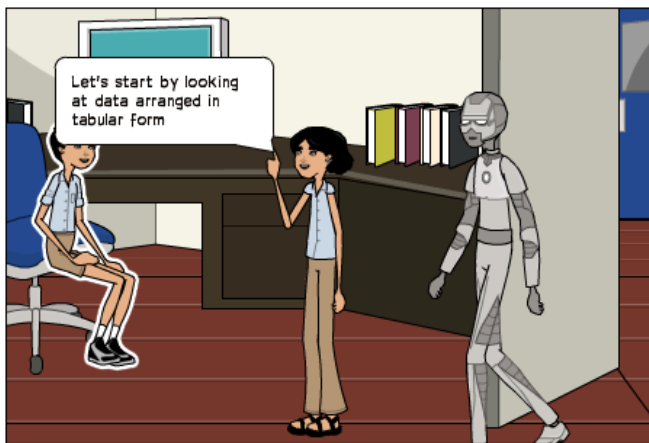
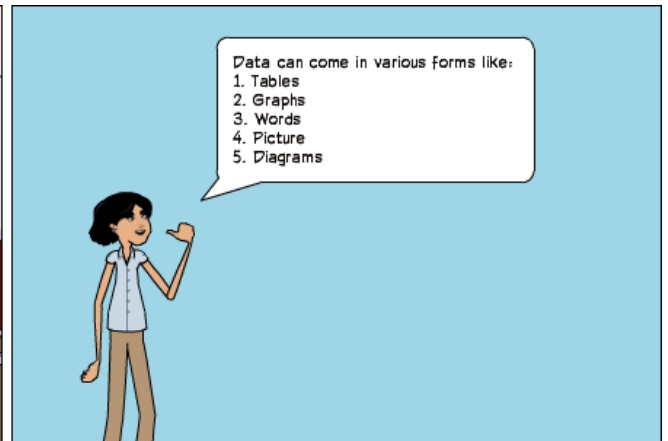
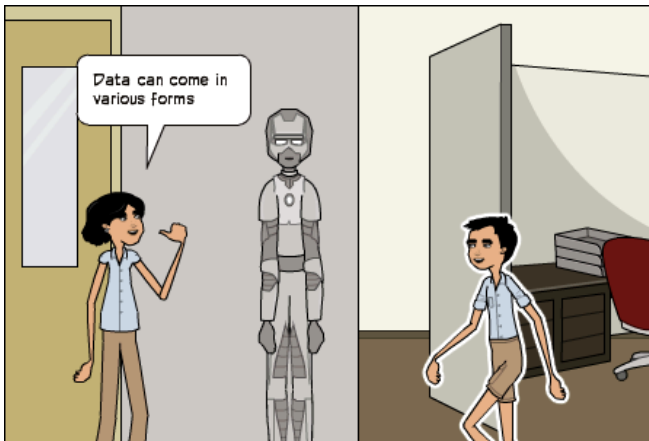
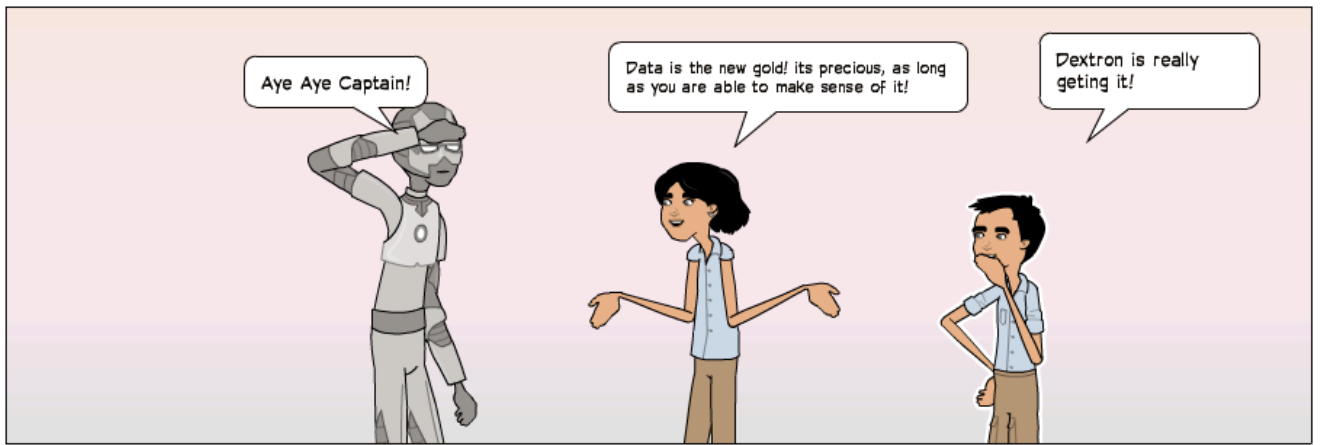
The SuperSave supermarket sells Birma washing powder for Rs 1.20 a bottle. At this price they are charging 50% more than the price at which they buy the item from the manufacturers. Next week SuperSave is having a 'Buy two get a third free' offer on this item. The supermarket does not want to lose money on this offer, so it expects the manufacturers to reduce their prices so SuperSave will make the same actual profit on every three bottles sold.

By how much will the manufacturers have to reduce their prices?

- (a) $1/6$
- (b) $1/4$
- (c) $1/3$
- (d) $1/2$
- (e) $2/3$

Itni shakti humein dena data





Types of exercise				
Age	Gym	Swimming	Jogging	Total
10 - 15	14	57	32	103
16 - 20	86	92	45	232
21 - 25	67	58	44	169
Total	167	207	130	504

And you would find that Jogging has a wrong entry. It should be 121 but it is 130

Types of exercise				
Age	Gym	Swimming	Jogging	Total
10 - 15	14	57	32	103
16 - 20	86	92	45	232
21 - 25	67	58	44	169
Total	167	207	130	504

Dextron, what should be the correct entry?

Because $130 - 121 = 9$ and $232 - 223 = 9$. Hence it must be 9 less than 45 i.e. 36

That was quite something!

Yeah! I felt like Sherlock Holmes!

Looking for clues! Trying to find hidden information

hahahaha

I don't understand human jokes! But it looks like Sherlock Holmes must be a detective!

Let's try data from a graph

What is the difference between the lowest average temperature and highest average temperature?

We need to find difference

What do we need to solve this problem?

You need to find the lowest average temperature and highest average temperature!

And then subtract them!

I am so proud of both of you!

and the highest average temperature is 34 degrees in April

Lowest average temperature is 14 degrees in December

And hence the answer is 20

What about words? How do you find data in words?

Let me give you an example of that as well! You guys are getting the hang of it!

In an inter-school hockey knockout competition, there are initially 32 teams. Teams are drawn by lots to play each other and the winner of each match goes through to the next round. This is repeated until there are only two teams left, who play each other in the final, and the winner gets a cup. Matches have two halves of 20 minutes each. If the teams are level at the end of normal play, two extra 10-minute periods are played. If it is still a draw, teams take penalty shots at goal to decide the winner.

High-school was eventually knocked out in the semi-final (without extra time). In one of the earlier rounds they had to play the two extra periods before they won.

For how long in total had High-school played when they were knocked out?

It might look intimidating and difficult in the beginning... But you need to give it just one good read and make notes

Okay... Let's start... In an inter-school hockey knockout competition, there are initially 32 teams.

There are 32 teams initially

Teams are drawn by lots to play each other and the winner of each match goes through to the next round. This is repeated until there are only two teams left, who play each other in the final, and the winner gets a cup.

Teams play with each other until only two teams play the final

Matches have two halves of 20 minutes each. If the teams are level at the end of normal play, two extra 10-minute periods are played.

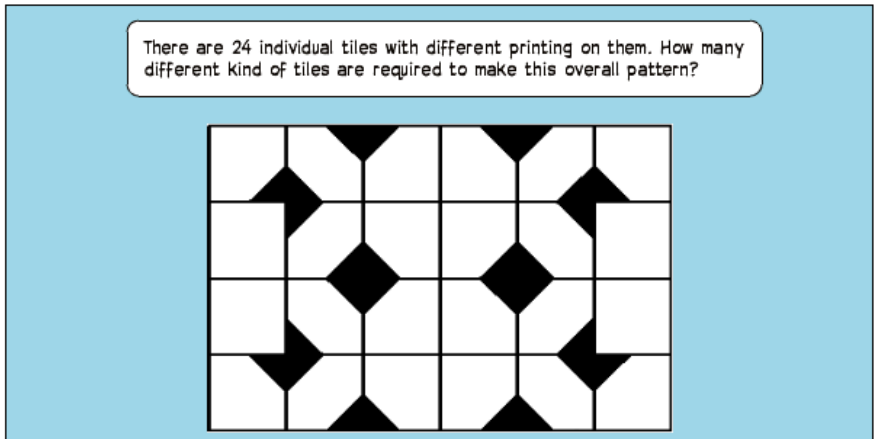
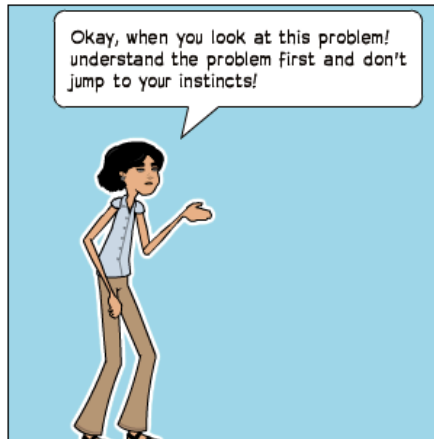
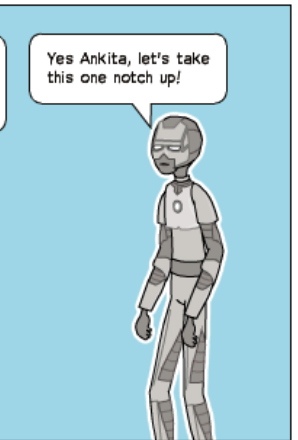
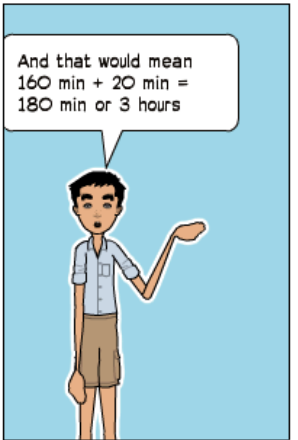
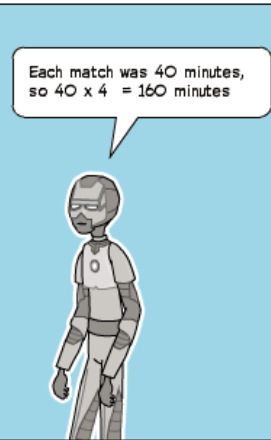
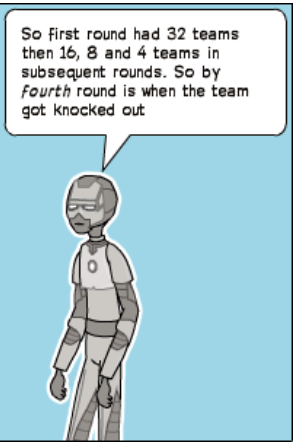
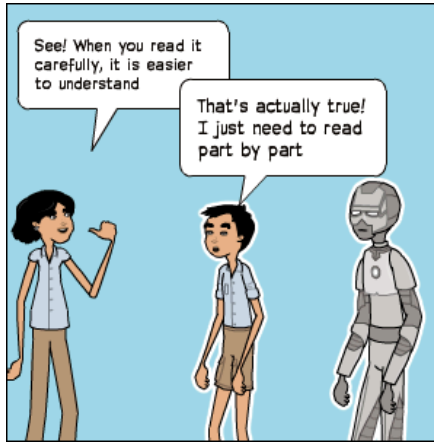
Normal match of 40 min if teams have similar scores, there can be 10 min or 20 min more given

If it is still a draw, teams take penalty shots at goal to decide the winner. High-school was eventually knocked out in the semi-final (without extra time).

High-school played till semi-finals

In one of the earlier rounds they had to play the two extra periods before they won.

High-school played two extra periods i.e. 20 min



You will have to think in steps. There are tiles that probably can be rotated and used.

Yes! The procedure is to eliminate tiles one by one, noting each time if a new tile can be used or a new tile is needed!

Let's start with the first tile. This will be unique!

The second tile is different from the first one. We would need this tile so let's keep it!

We can use the pattern in second tile to make third tile! So we will cross it!

Tile 2 can be used to get this

Tile 1 can be rotated to get this

And if you continue to do this you will get

You will get three unique patterns which can be used to make the 24 tiled pattern

This was so much fun! What else do you have in your hat?

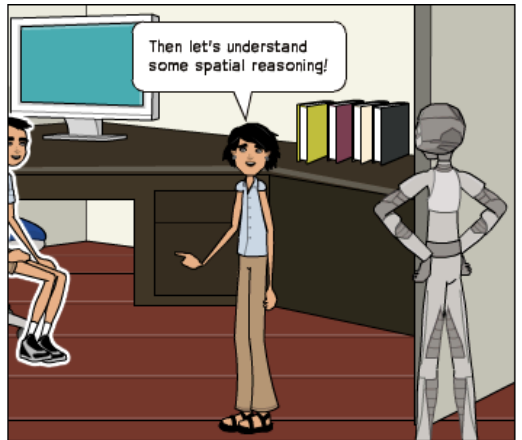
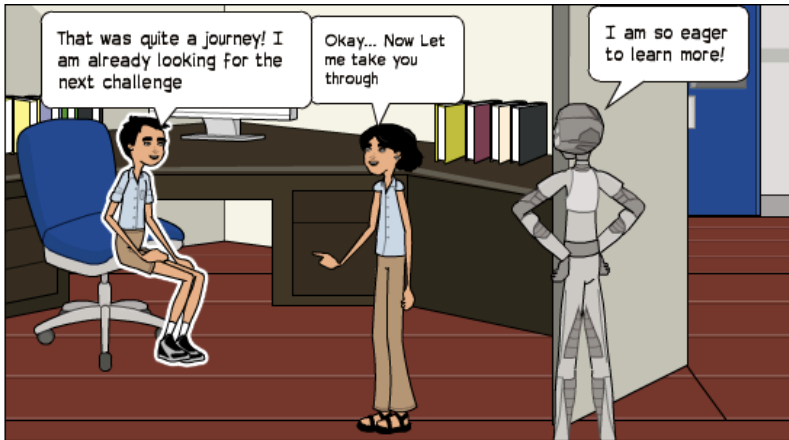
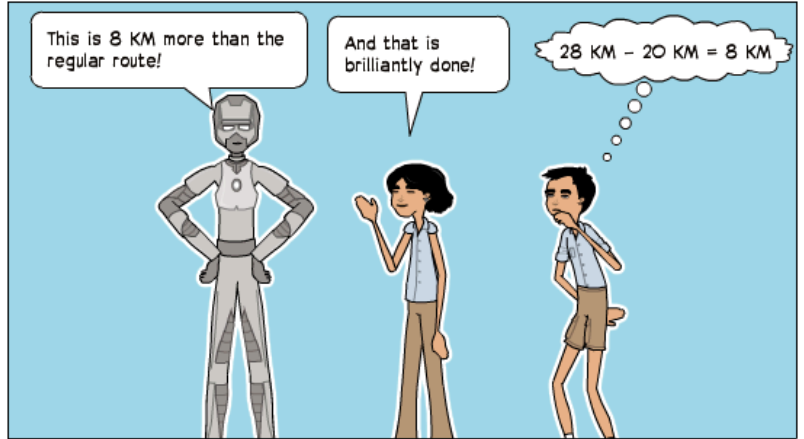
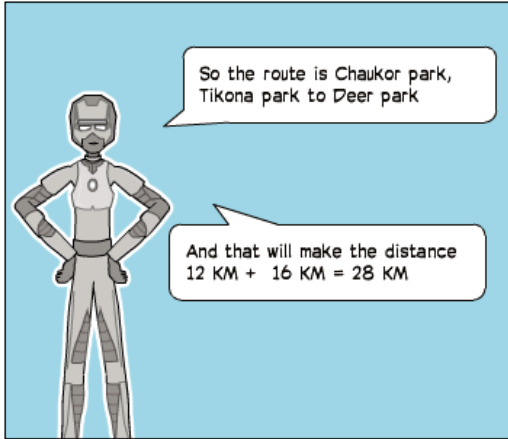
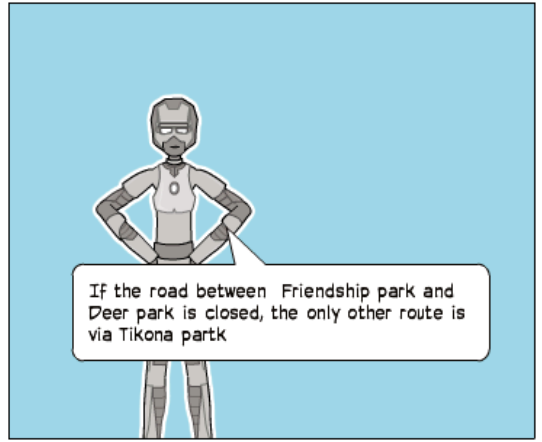
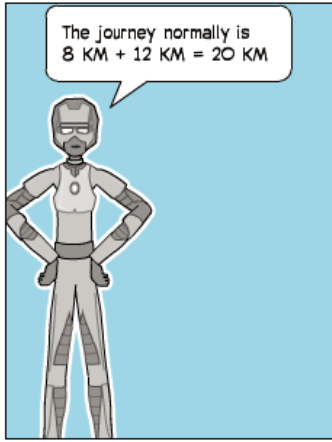
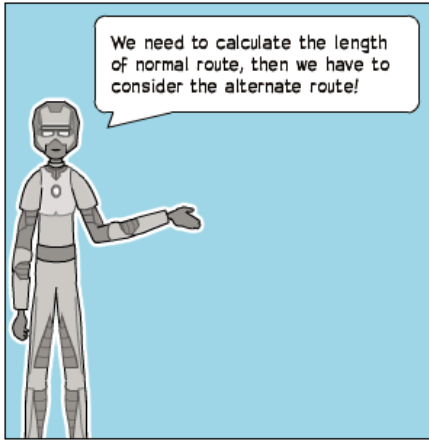
Hahahah... Well the next thing you both should try is extracting information from a diagram!

Let's do it!

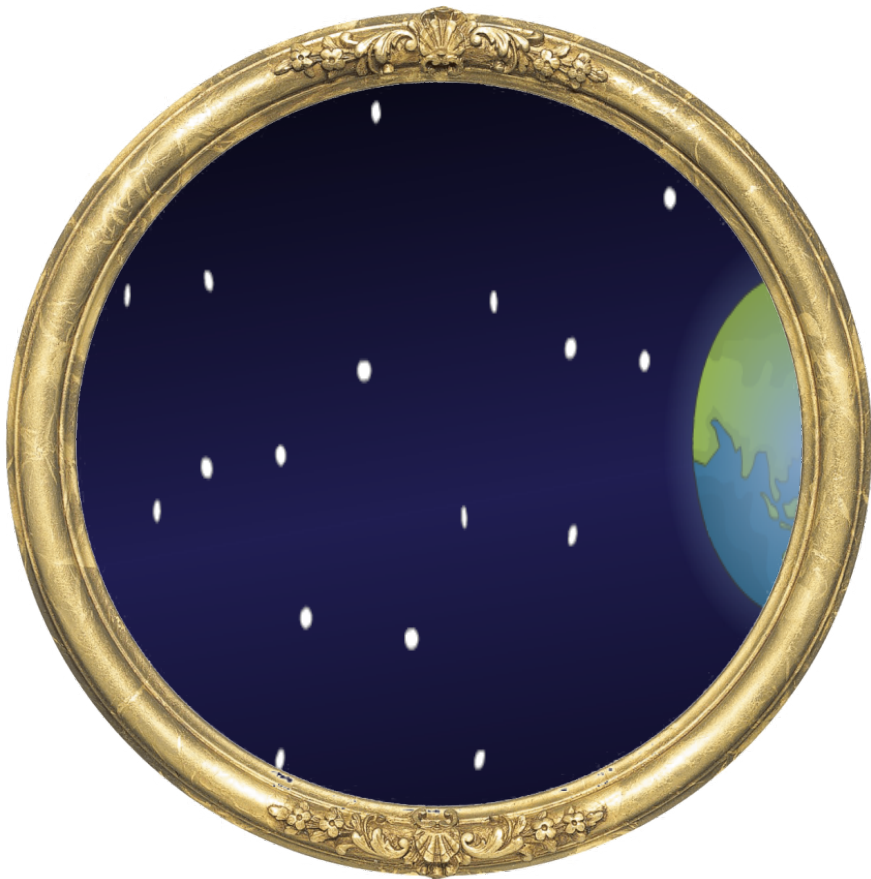
What else do you have in your hat is a phrase used to say what is the next thing you will bring up

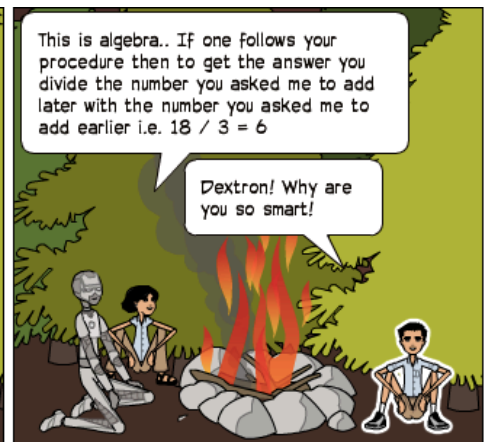
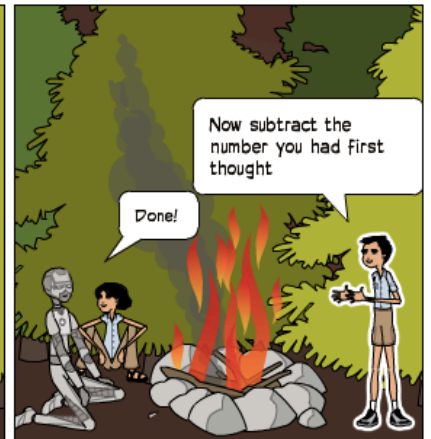
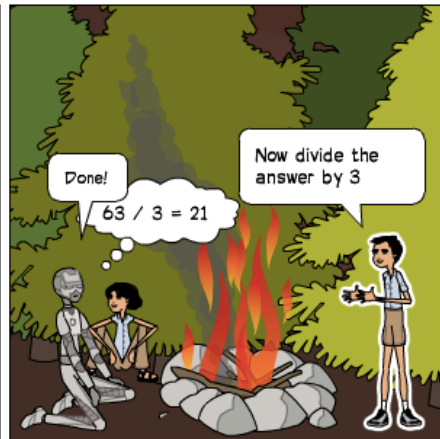
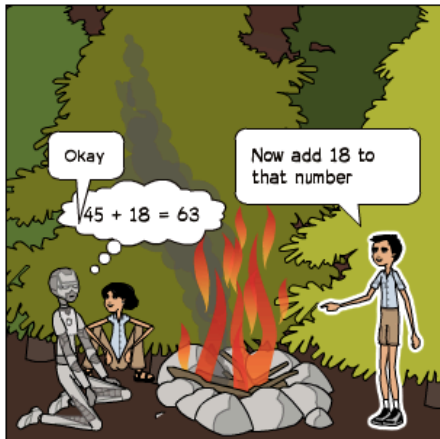
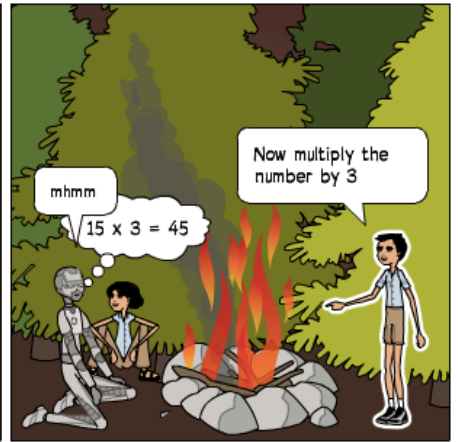
I live in Chaukor park and wish to visit a friend in Deer park. I normally go via Friendship park but have discovered (before setting off) that the road between Friendship park and Deer park is blocked by an accident. How much will this add to my journey?

This one is easy!

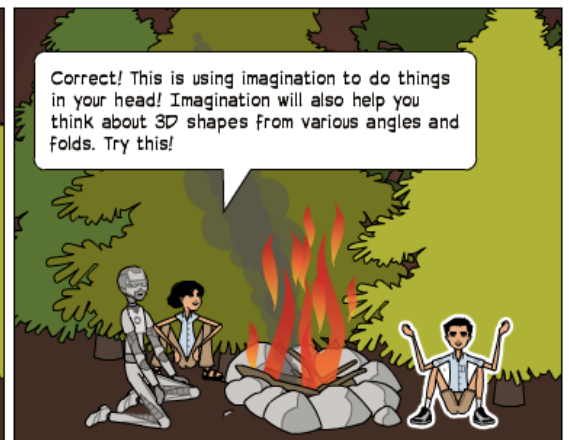
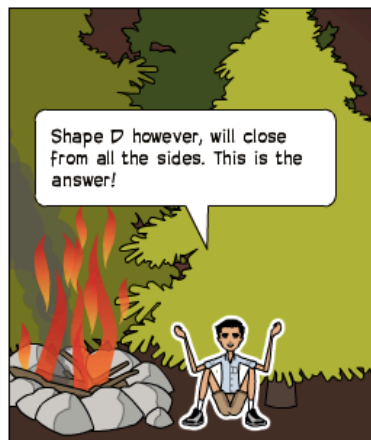
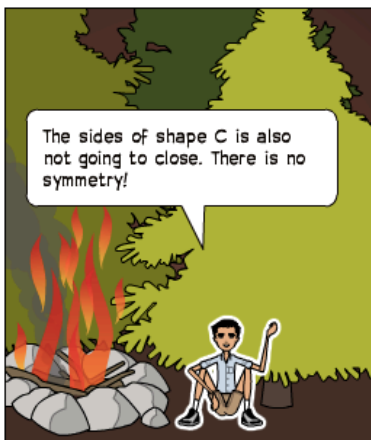
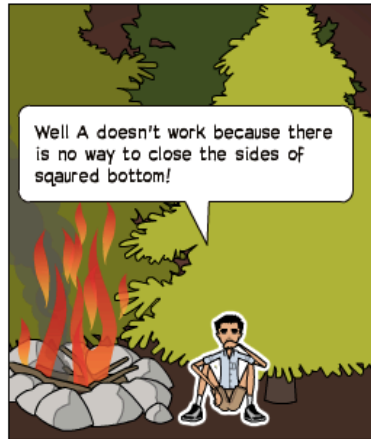
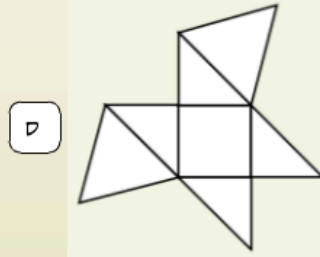
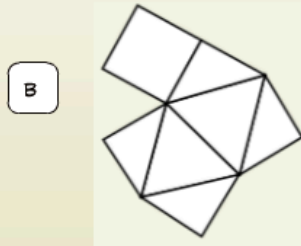
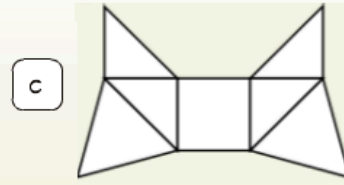
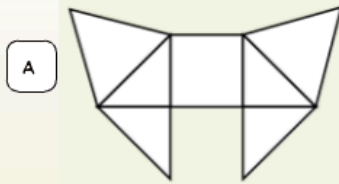
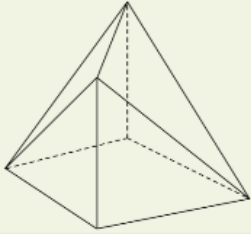


Give me some space!

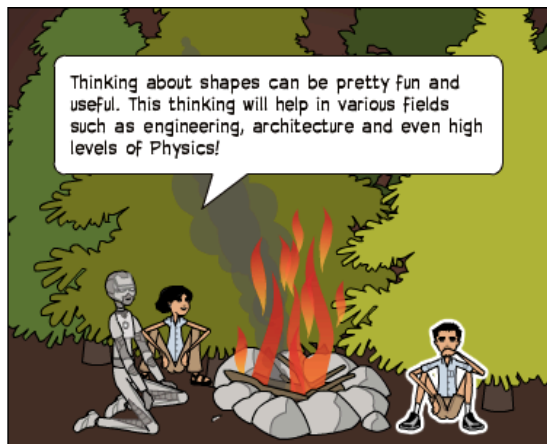
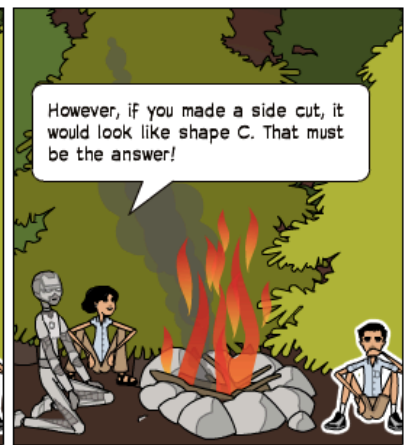
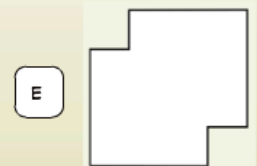
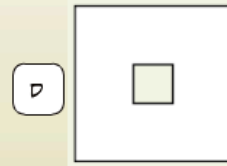
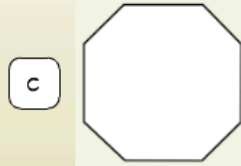
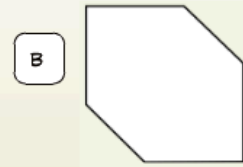
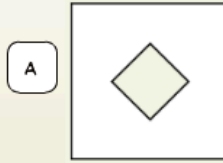
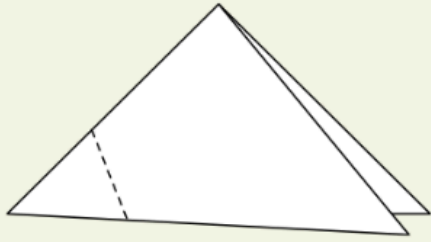




This is a 3 dimensional shape! Which of the following pieces of cardboard shape will fold to make the shape?

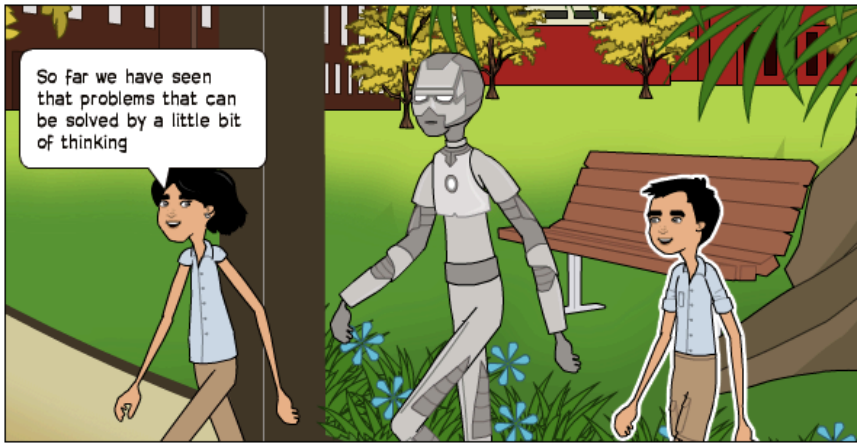


Some children are making decorations. A square sheet of paper is folded along a diagonal and then again so the two sharp points meet, as shown. A cut is made through all the layers of paper along the dotted line shown and the small pieces removed. The paper is then opened. What does it look like?

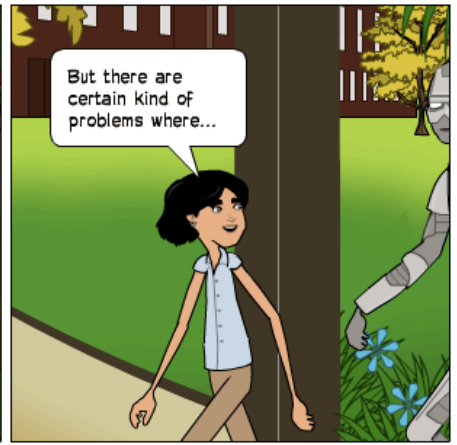


**If you can't solve it,
search for it!**

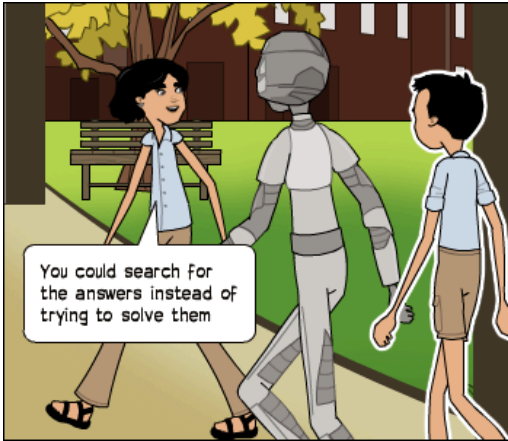




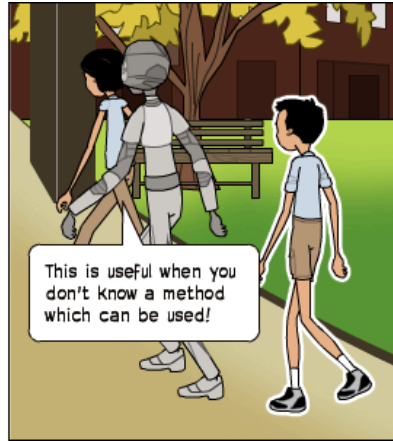
So far we have seen that problems that can be solved by a little bit of thinking



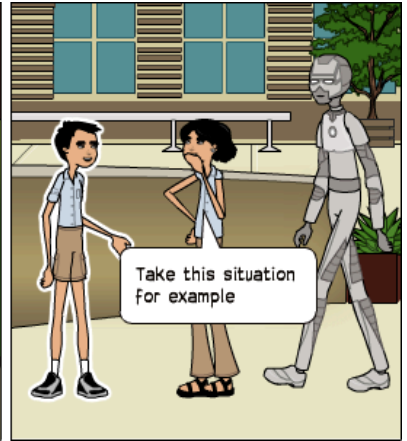
But there are certain kind of problems where...



You could search for the answers instead of trying to solve them



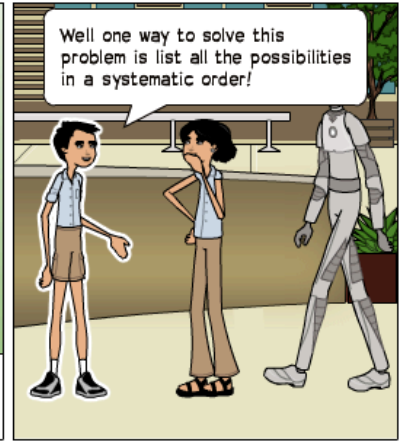
This is useful when you don't know a method which can be used!



Take this situation for example

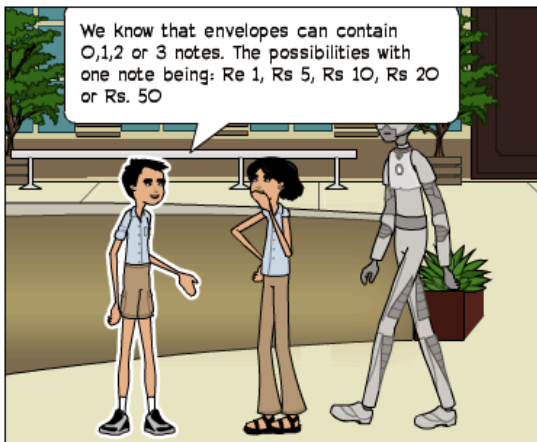
Amir is helping with a charity collection and has gathered envelopes containing rupee notes from a number of donors. He notes that all the envelopes contain exactly three items but some of them contain one, two or three buttons instead of rupee notes. This is probably from people who did not want to donate. All the notes have denominations of Re 1, Rs 5, Rs 10, Rs 20 or Rs 50. If Amir counted the value of each envelope, what is the smallest amount that he will not find in any envelope?

How would you solve this?

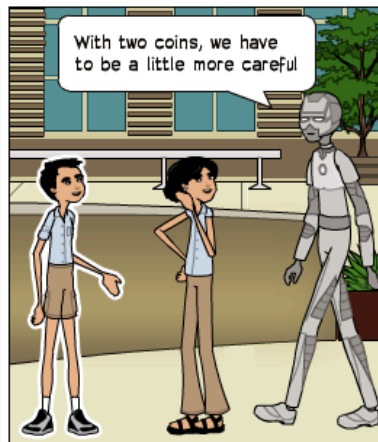


Well one way to solve this problem is list all the possibilities in a systematic order!

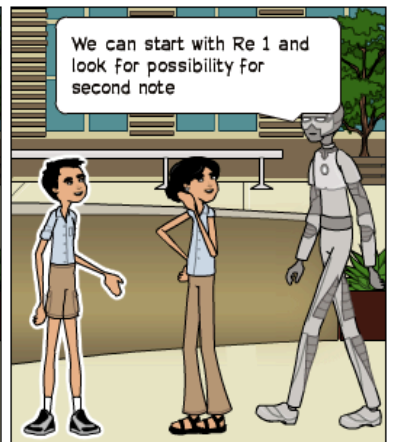
Explanation: Each envelope can have a different value starting from as low as Re 1 to as high as Rs 150. But there are value that Amir can not find in the envelope. For example, Amir can not find Rs 14 in any note as he would need Rs 10 and four Re 1 note and each envelop has three notes maximum.



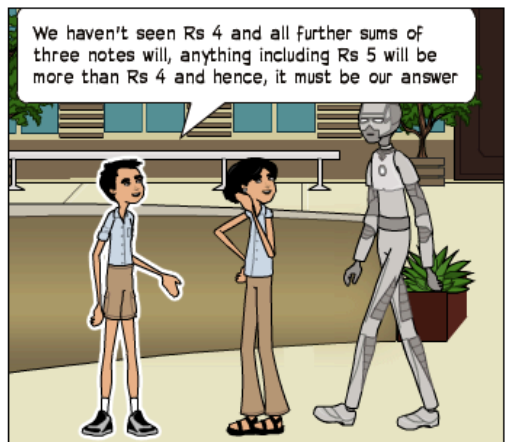
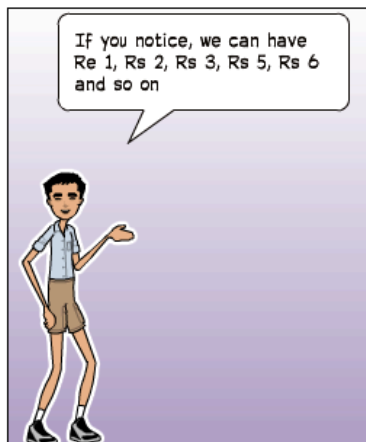
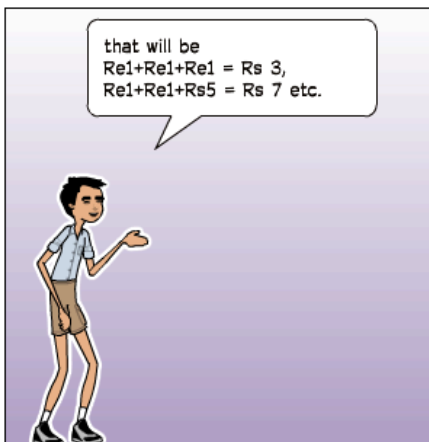
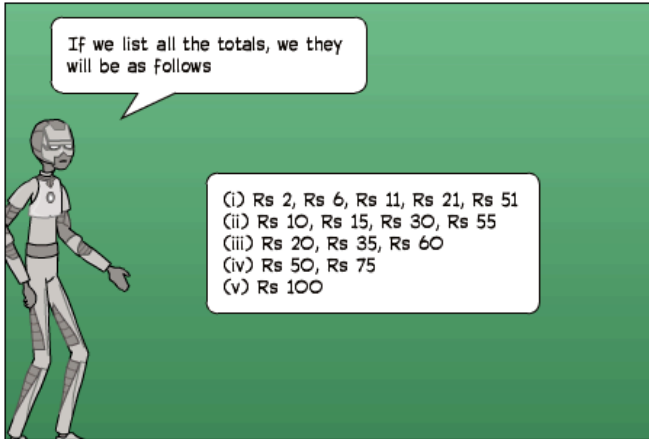
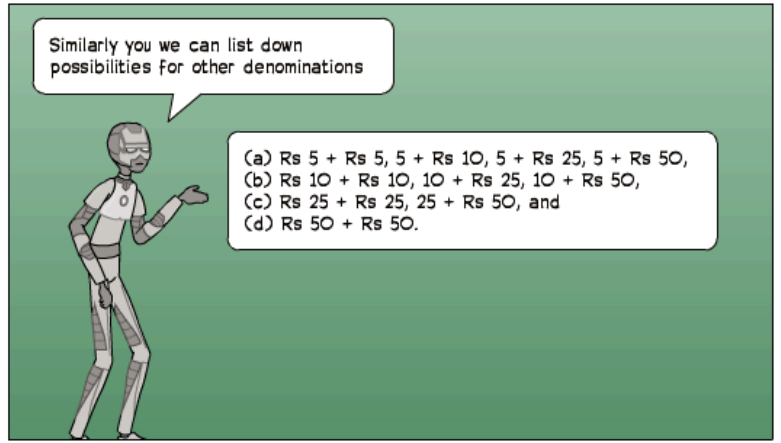
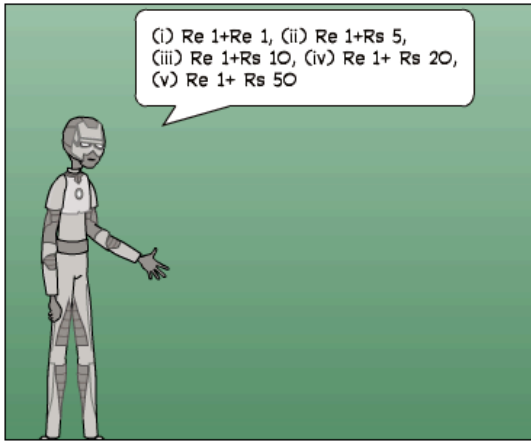
We know that envelopes can contain 0, 1, 2 or 3 notes. The possibilities with one note being: Re 1, Rs 5, Rs 10, Rs 20 or Rs. 50



With two coins, we have to be a little more careful



We can start with Re 1 and look for possibility for second note

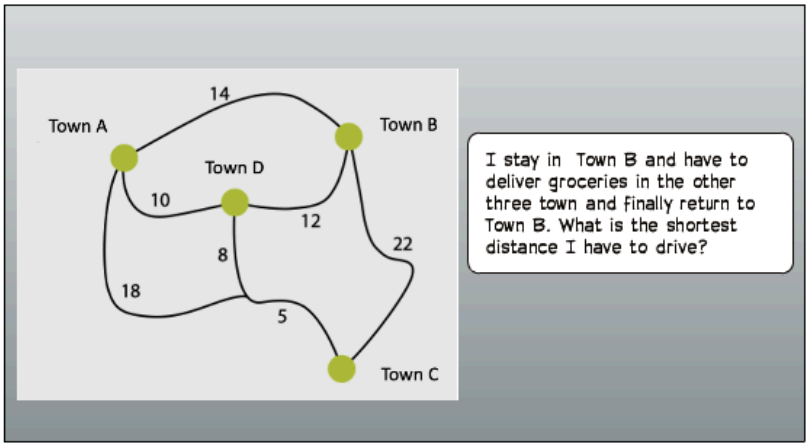
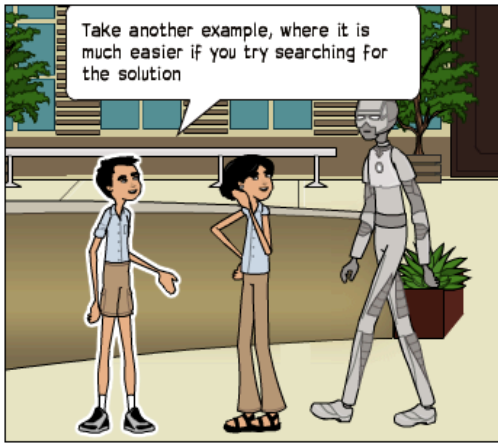


If you list down all the values that envelop can have:

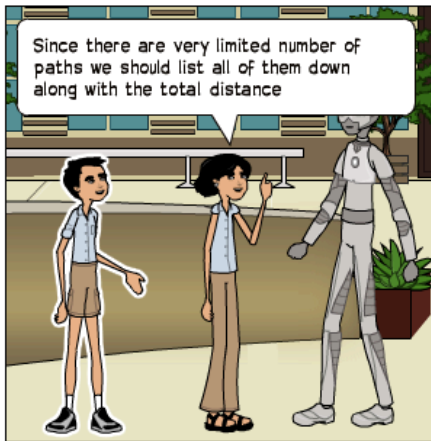
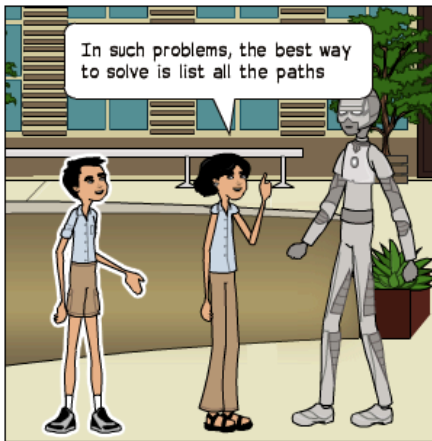
Re 1, Rs 2, Rs 3, Rs 4, Rs 5, Rs 6, Rs 7, Rs 8, Rs 9 and so on

Then you can start striking off the numbers that you have found as the problem asks you to find the number that is not possible to get in the envelope. In this case:

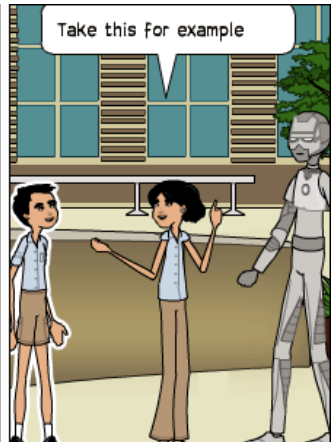
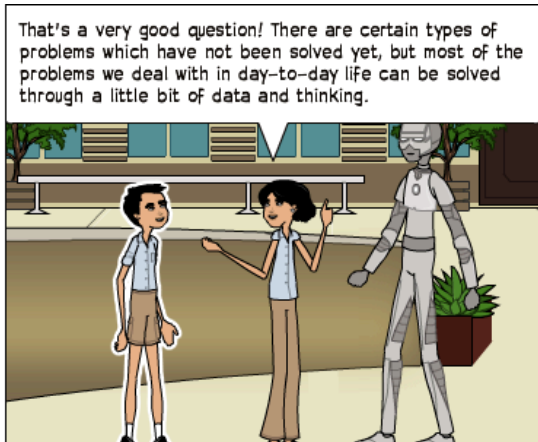
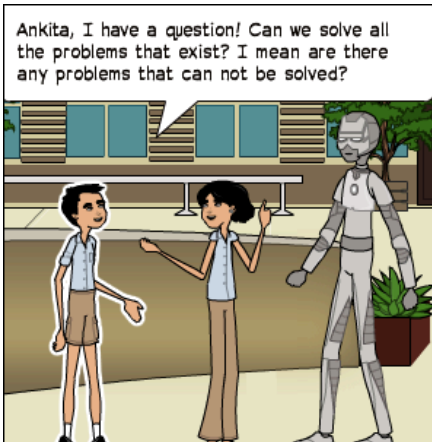
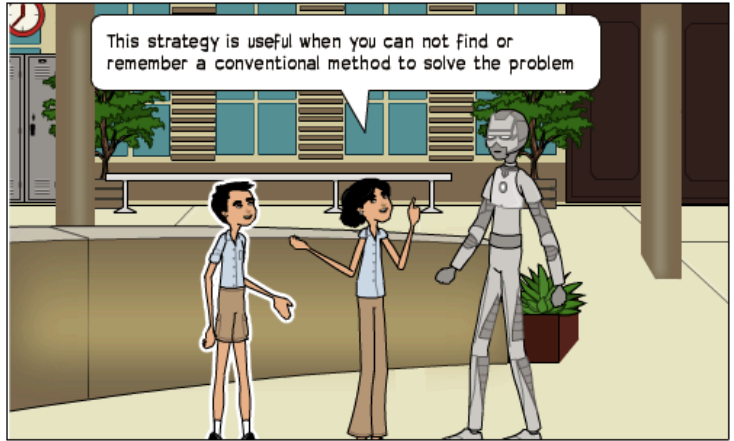
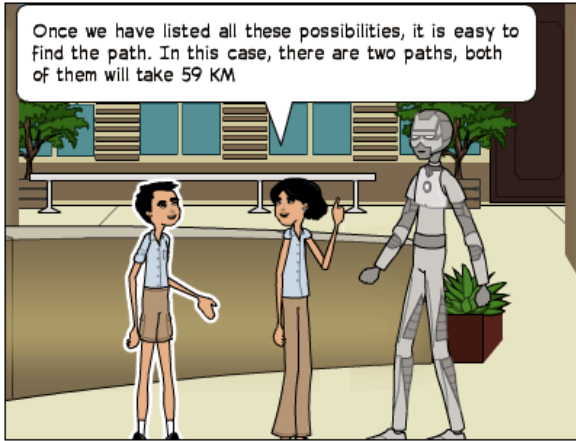
~~Re 1, Rs 2, Rs 3, Rs 4, Rs 5, Rs 6, Rs 7, Rs 8, Rs 9~~ and so on



I stay in Town B and have to deliver groceries in the other three town and finally return to Town B. What is the shortest distance I have to drive?



- These are all the possible paths
- BADCB = $14+10+8+5+22 = 59$
 - BACDB = $14+18+5+5+8+12 = 62$
 - BDACB = $12+10+18+5+22 = 67$
 - BDCAB = $12+8+5+5+18+14 = 62$
 - BCDAB = $22+5+8+10+14 = 59$
 - BCADB = $22+5+18+10+12 = 67$



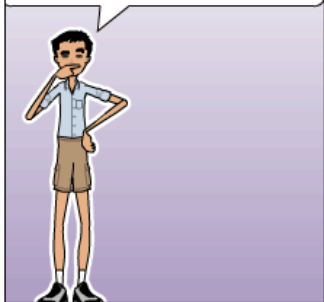
I use the trip meter on my car to measure the distance driven since I last had the car serviced, so that I know when the next service is due. The trip meter can be set to zero by the press of a button and records the kilometres driven since it was last reset.

I set the trip meter to zero after my last service. The next service is due after 20,000 km have been driven. Some time later, I lent the car to my brother. I forgot to tell him about the trip meter; he pressed the button to zero it and drove 575 km. I then started driving again without realising what he had done.

What should the trip meter read when the next service is due?

The above problem cannot be solved with the information given. What additional piece of information is needed to solve it?

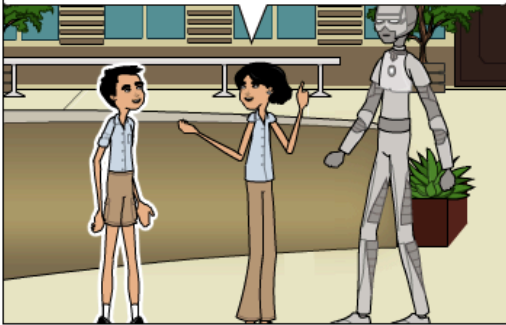
hmm....The distance driven from the last service when your brother returned the car was the distance you had driven plus the distance he had driven.



I know how far he had driven, so what I need to know was the distance on the trip meter when you gave the car to your brother.



In this example, the data was not sufficient to solve the problem. If you read the problem carefully, you will be able to find if the data is sufficient or not to solve the problem!



Why don't you try this problem by yourself and see if you can find the answer?



I have a small collection of three different types of old coin (1 paisa coins, 2 paisa coins and 5 paisa coins). The collection contains 15 coins in total. There are more 1 Paisa coin than 2 Paisa coins and more 2 Paisa coins than 5 Paisa coins. Which one of the following single pieces of information would enable you to know exactly how many of each type of coin there was?

(a) There are four more 2 Paisa coin than 5 Paisa coins

(c) There are three more 1 paisa coin than 2 paisa coins.

(b) There are five more 1 paisa coin than 5 paisa coins

(d) There is one less 1 paisa coin than 5 paisa coins and 2 paisa coins together.

You can apply the same strategy we used earlier. Search for the solution



1 paisa coin	2 paisa coin	5 paisa coin
12	2	1

Acknowledgement

We acknowledge the work done by Mr. John Butterworth and Mr. Geoff Thwaites on critical thinking through their book - Thinking Skills (Critical Thinking and Problem Solving)

This book has been a big source of inspiration for this book

Additional resources

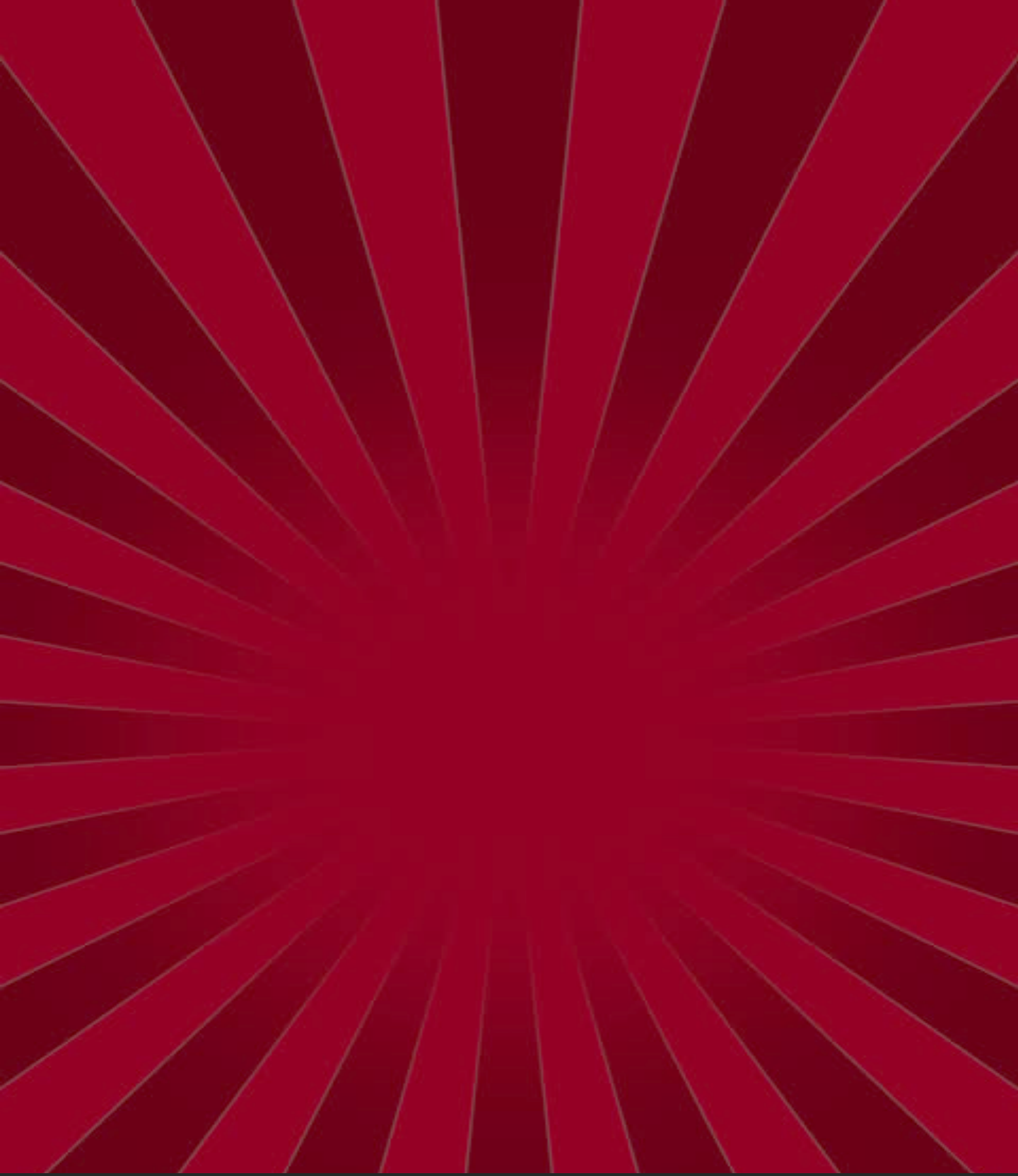
Readings

1. Hands on Maths
2. Mathematics Can Be Fun
3. Great Ideas of Modern Mathematics
4. Polya's Problem Solving strategy

Videos

1. [TED-Ed - Riddles](#)
2. [TED-Ed - Think like a coder](#)

We thank all the contributors for making the above resources available on the internet. We specially thank Dr. Arvind Gupta for making excellent learning resources available for free on the internet.



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