How to solve it

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How to solve it

• George Polya wrote a book on the method for solving mathematical problems.

• The book has been very successful. In fact, so successful that people from other areas borrowed the notions behind “How to solve it,” including
  – architecture,
  – software development,
  – artificial intelligence, etc.
Four steps in *How to solve it*

- Understand the problem
- Devise a plan
- Carry out the plan
- Look back
Planting trees along a pond

- A pond with a circumference of 100m long. If we were to plant a tree for every two meters around the pond, how many trees are planted?
Understand the problem

How many?
Devise a plan: analogy

Ans: 5
Carry out the plan

\[ 10/2 = 5 \quad \Rightarrow \quad 100/2 = 50 \]
Look back

5 is indeed correct 10 m, therefore 50 for 100m. Voila!
How to solve it in programming

• Understand the problem
  – Really understand the problem

• Devise a plan
  – Write the main program
  – List the tasks required to make the main program work

• Carry out the plan
  – Code it up

• Looking back
  – Test it
Understand the problem

• Compute the dot product of two vectors of the same dimension. For example,

\[(1, 0) \times (1, 1) = 1\]
\[(1, 1, 0) \times (0, 1, 1) = 1\]
\[(1,0)\times(1,1,0)\text{ is illegal}\]

• What is a vector? Ordered \(n\)-tuple of real numbers
• What is the dimension of a vector? \(\text{Dim} \ (1, 1, 0) = 3\)
• What is dot product?

\[\mathbf{a} \cdot \mathbf{b} = \sum_{i=1}^{n} a_i b_i = a_1 b_1 + a_2 b_2 + \cdots + a_n b_n,\]

• Can we compute dot product for vectors of different dimensions?
Devise a plan – list the tasks

1. As a programmer, I can write the main program
2. As a programmer, I can define a n-dimensional vector.
3. As a programmer, I can define a n-dimensional vector with given values for its components
4. As a programmer, I can print a vector.
5. As a programmer, I can compute the dot product of two vectors of the same dimension
6. As a programmer, I can display a dot product
Carry out the plan

• Write code for each of the tasks
• You will come back to the task “As a programmer, I can write the main program” as needed.
• Next slide reflects main after completing task 2 and 3:

1. As a programmer, I can write the main program
2. As a programmer, I can define a n-dimensional vector.
3. As a programmer, I can print a vector.
4. As a programmer, I can compute the dot product.
5. As a programmer, I can display a dot product.
6. As a programmer, I can detect if two vectors are orthogonal.
As a programmer, I can write the main program

```c
int main(int argc, char *argv[]) {
    double v1[2] = {1.0, 0.0};
    double v2[2] = {1.0, 1.0};
    double v3[3] = {1,1,0};
    double v4[3] = {0,1,1};

    printVector(v1, 2);
    printVector(v2, 2);
    printVector(v3, 3);
    printVector(v4, 3);

    // oops
    printVector(v1, 3);
    printVector(v3, 2);
```
As a programmer, I can print a vector

• Task 4 is created partly to check task 3 (creating vectors)

```cpp
void printVector(double v[], int dim)
{
    cout << "(";
    for (int i=0; i< dim-1; ++i)
        cout << v[i] << ",";
    cout << v[dim-1] << ")" << endl;
}
```
Look back - testing

• Test every task
• Be picky (but with reason); ask for trouble!
Look back – can we do better?

• Double arrays as mathematical vectors? Hard to swallow??

```java
16    double v1[2] = {1.0, 0.0};
17    double v2[2] = {1.0, 1.0};
18
19    double v3[3] = {1,1,0};
20    double v4[3] = {0,1,1};
```

• Can we write vector so that it carries its own dimension? e.g.

```java
printVector(v1);
```
Model of a variable

```
int numDays = 365;
int * p = &numDays;
```
model of array

int a[4] = {2, 3, 5, 7};

What is the type of a?

1. int
2. int *
3. const int *
4. int * const

A constant pointer to integers

const double pi = 3.14159;
const double *const pi_ptr = &pi;

Too low level!
Create new tasks if you are not satisfied.

• Add the following tasks:
  – As a programmer, I can define vectors that carries its own dimensionality.

• To accomplish the task you need more from C++
  – struct
  – class
Concluding remarks

• Always do the four steps
• In particular, write down the tasks of steps 2 in a file, say in “todo.txt.”
• Go through the tasks in “todo.txt” one by one
  – Code it
  – Compile it (comment out unfinished lines in main to make it work)
  – Test it (using main or CppUnitLight test case)
• Until all tasks are done and results are correct