Project 3: Dynamic Programming

Group 9, Lab Group SS1
CZ2002

Unbounded Knapsack Problem

(Unlimited == Unbounded)

Subproblem Graph

	0	1	2
wi	4	6	8
pi	7	6	9

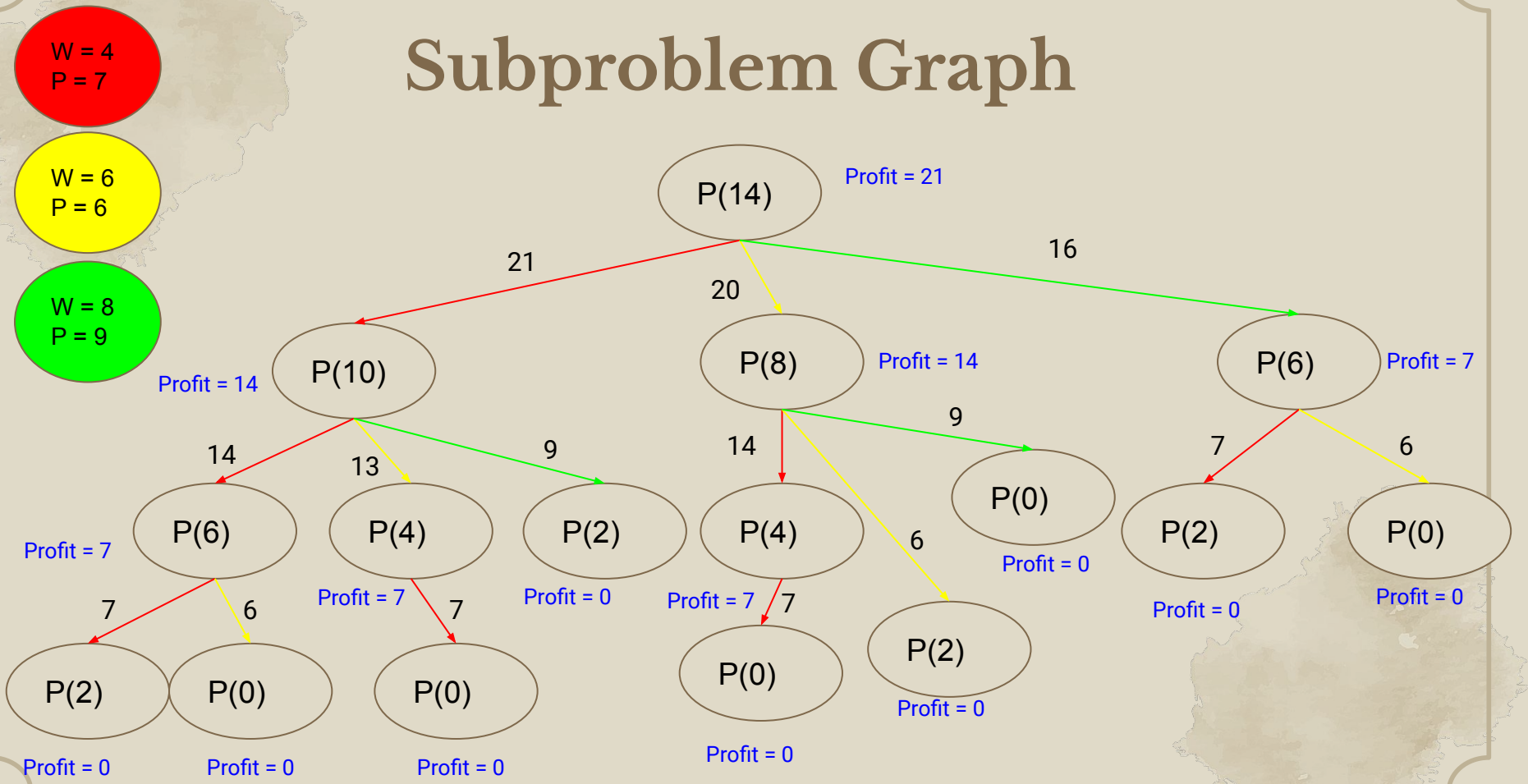
Definitions:

- **P(C): Maximum profit at particular C value (Dependent on `w[i]` and `p[i]`)**
- **C: Capacity of knapsack (Dependent on `w[i]`)**

Mechanics:

1. When C = 0 or can no longer be reduced by any of the weight, P(C) = 0
2. Return to previous state, save the profit of the weight that led to dead end.
3. Continue down alternative paths with other weights and repeat (1) and (2)
4. Compare the profits and save the higher profit.
5. Rinse and repeat 1-5 until function returns back to starting point with max profit

Subproblem Graph



Dynamic Programming Algorithm

1. Create a new array `soln` of size C+1. The array indicates the maximum profit we can achieve with a knapsack capacity.

   `soln[i]` = max profit with a knapsack of capacity i

   Aim is to find `soln[C]`

   Initialise the array to zeros

2. We iterate over all the elements available for each knapsack capacity between 1 to C and determine if it can be used to achieve a greater profit
3. The recurrence relation would be

```
soln[i] = max(soln[i], soln[i-w[j]] + p[j])
```

if `w[j] < i` => item j is taken

Dynamic Programming Recurrence Relation

```
soln[i] = max(soln[i], soln[i-w[j]] + p[j])
```

Implementation in code

```
public static void UnboundedKnapsack (int [] w, int [] p, int C, int n)
{
    System.out.println("-----------------------------------------------------");
    System.out.println("The problem is P("+n+","+C+") : Unbounded Knapsack");

    long start = System.nanoTime();

    int r, c;
    int soln[] = new int[C+1];

    for(r = 0; r <= C; r++)
    {
        for(c = 0; c < n; c++)
        {
            if(w[c] <= r)
            {
                if(soln[r] < soln[r - w[c]]+ p[c])
                {
                    soln[r] = soln[r - w[c]]+ p[c];
                }
            }
        }
    }
    long end = System.nanoTime();
    long timeElapsed = end - start;

    System.out.println("The solution is "+ soln[C]);
    System.out.println("Execution time in seconds: " + (double)timeElapsed / 1000000000);
}
```

Complexity Analysis

```
public static void UnboundedKnapsack (int [] w, int [] p, int C, int n)
{
    System.out.println("----------------------------------------------------");
    System.out.println("The problem is P("+n+","+C+") : Unbounded Knapsack");

    long start = System.nanoTime();

    int r, c;
    int soln[] = new int[C+1];

    for(r = 0; r <= C; r++)
    {
        for(c = 0; c < n; c++)
        {
            if(w[c] <= r)
            {
                if(soln[r] < soln[r - w[c]]+ p[c])
                {
                    soln[r] = soln[r - w[c]]+ p[c];
                }
            }
        }
    }
    long end = System.nanoTime();
    long timeElapsed = end - start;

    System.out.println("The solution is "+ soln[C]);
    System.out.println("Execution time in seconds: " + (double)timeElapsed / 1000000000);
}
```

O(C+1)

O(n)

Constant time

Total time complexity = O(Cn)

Total space complexity = O(C)

Results using Dynamic Programming

	0	1	2
w_i	4	6	8
p_i	7	6	9

```
Enter the value of C: 14
Enter the value of n: 3
Enter the value(s) of weights:
4
6
8
Enter the value(s) of profits:
7
6
9
--------------------------------------------------
The problem is P(3,14) : Unbounded Knapsack
The solution is 21
Execution time in seconds: 6.3E-6
```

	0	1	2
w_i	5	6	8
p_i	7	6	9

```
Enter the value of C: 14
Enter the value of n: 3
Enter the value(s) of weights:
5
6
8
Enter the value(s) of profits:
7
6
9
--------------------------------------------------
The problem is P(3,14) : Unbounded Knapsack
The solution is 16
Execution time in seconds: 3.1E-6
```

The End
Q&A

This Is a Map

Venus

Venus is the second planet from the Sun

Mercury

Mercury is the smallest planet

Earth

Earth is the only planet with life

Literature Review

Theory 01

Mercury is the closest planet to the Sun and the smallest of them all

Theory 02

Despite being red, Mars is actually a cold place full of iron oxide dust

Secondary Objectives

Mercury

Mercury is the closest planet to the Sun

Venus

Venus has a beautiful name and is the second planet

Mars

Despite being red, Mars is actually a cold place

Saturn

Saturn is a gas giant and has several rings

Earth

Earth is the third planet from the Sun

Jupiter

Jupiter is a gas giant and the biggest one

Awesome Words

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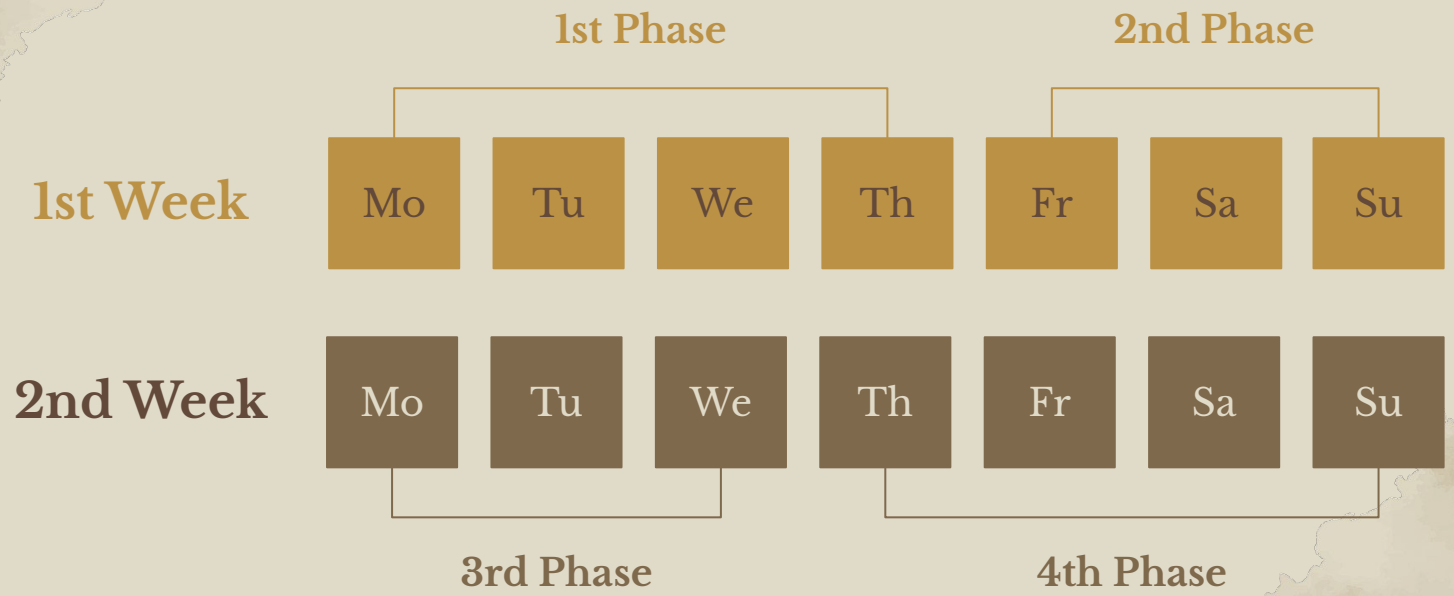
A Picture Is Worth a Thousand Words

Schedule


1st Phase
2nd Phase
1st Week
Mo
Tu
We
Th
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Su
2nd Week
Mo
Tu
We
Th
Fr
Sa
Su
3rd Phase
4th Phase

1,927

Big numbers catch your audience's attention

Table

	Test 1	Test 2	Test 3	Test 4
Indicator 1	✓	✓	✓	✓
Indicator 2	✗	✗	✓	✗
Indicator 3	✗	✓	✓	✗
Indicator 4	✓	✗	✗	✓

Timeline

Mercury

Mercury is the closest planet to the Sun

1927

Now

Venus

Venus is the second planet from the Sun

Mars

Mars is actually a very cold place

2027

A Picture Always Reinforces the Concept

Images reveal large amounts of data, so remember: Use an image instead of a long text

Important Percentages

33.5%

Mercury is the closest planet to the Sun

26.7%

Despite being red, Mars is a cold place

18.2%

Saturn is the ringed one and a gas giant

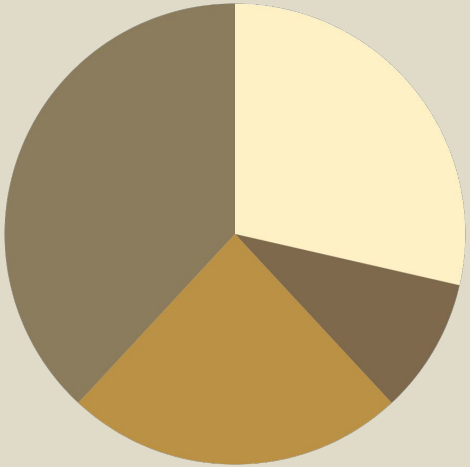
Methodology

Research

Venus has a beautiful name, but it's terribly hot

Analysis

Jupiter is the biggest planet in the Solar System



Data Study

Despite being red, Mars is actually a cold place

Comparison

Saturn is the ringed one and a gas giant

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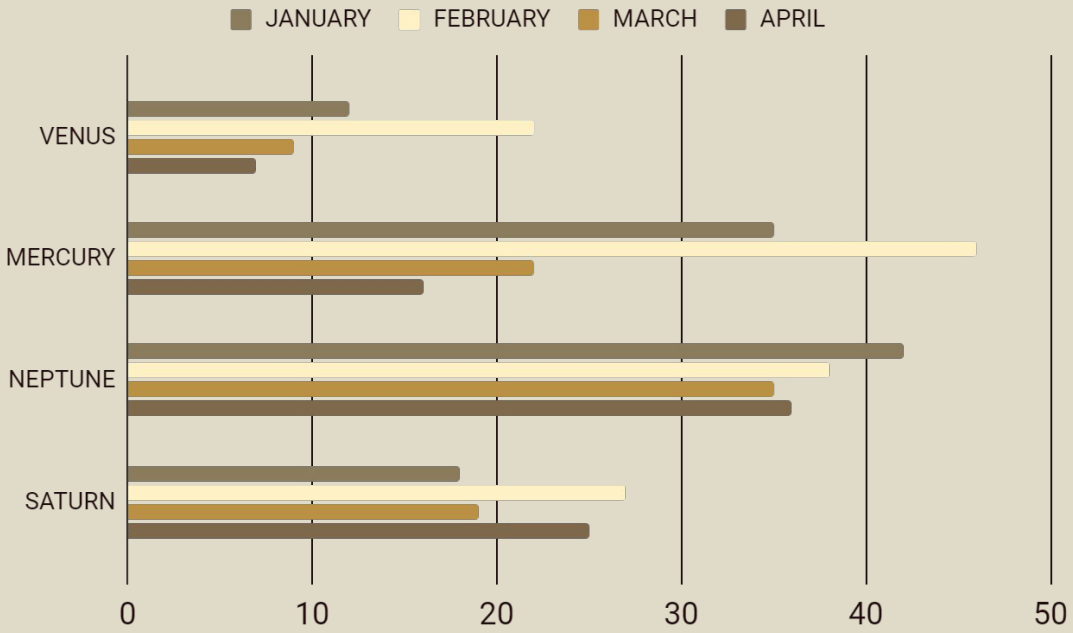
Results Analysis



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Conclusions

Conclusion A

Here you can talk about the conclusions

Conclusion C

Here you can talk about the conclusions

Conclusion B

Here you can talk about the conclusions

Conclusion D

Here you can talk about the conclusions

Thanks

Do you have any questions?
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Alternative Resources

Vectors

- Hand drawn international literacy day
- International literacy day with stack of books
- International literacy day draw

Photos

- Bunch of old books
- Pile of books on blue background
- Smoke over antique notebook and ink pen

Resources

Vectors

- Glasses with books for literacy day
- International literacy day with lots of books
- International literacy day celebration

Photos

- Glasses on old books in library
- Old books on library table
- Ink pen on opened old notebook

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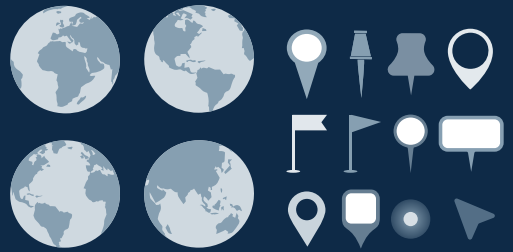

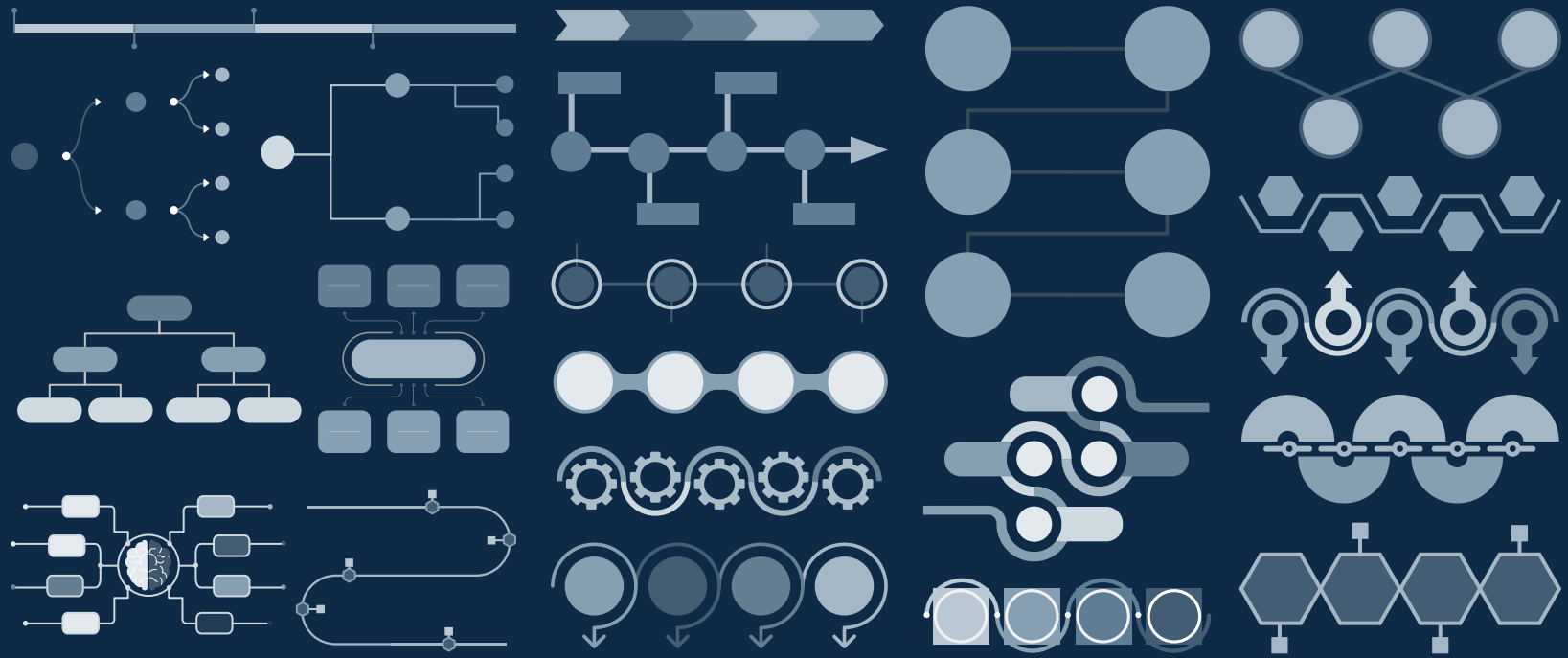

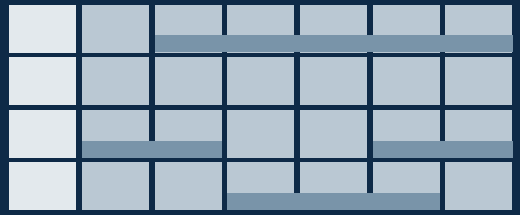

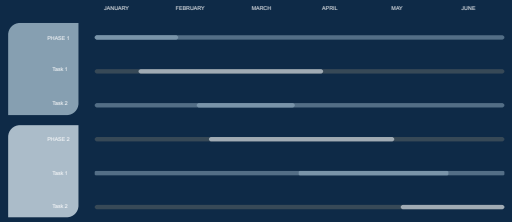
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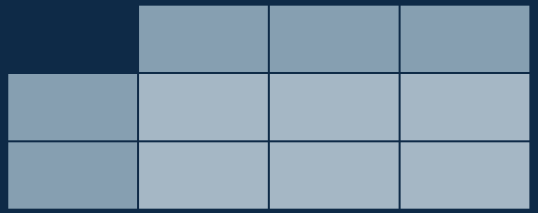

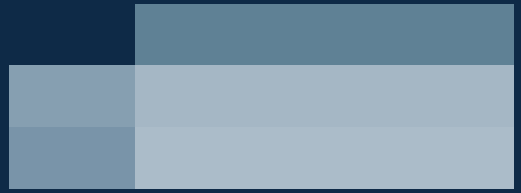

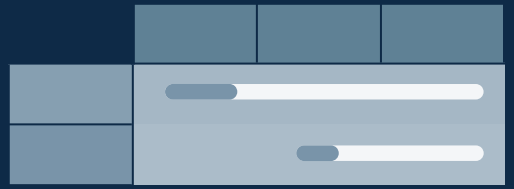

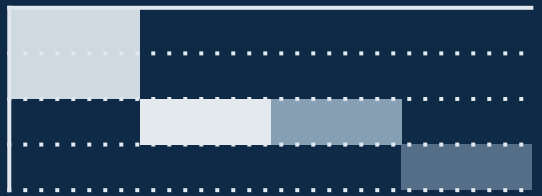

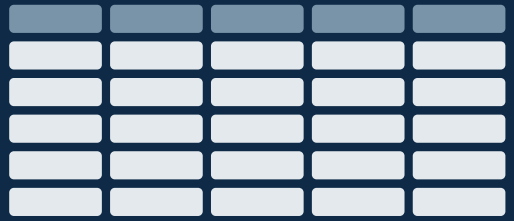

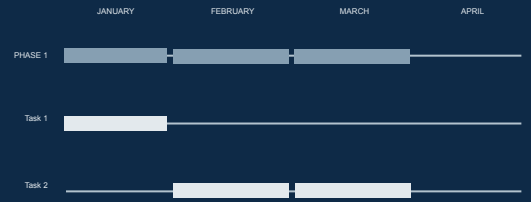
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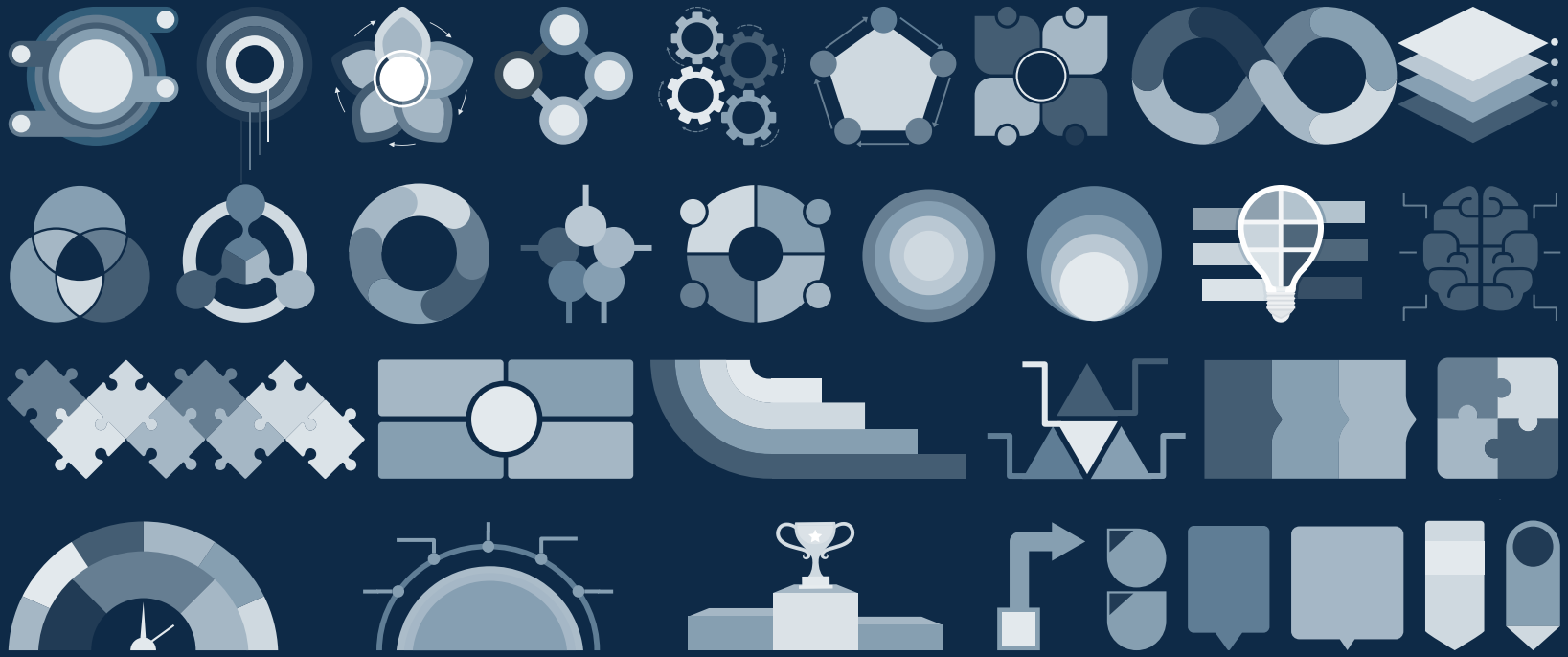

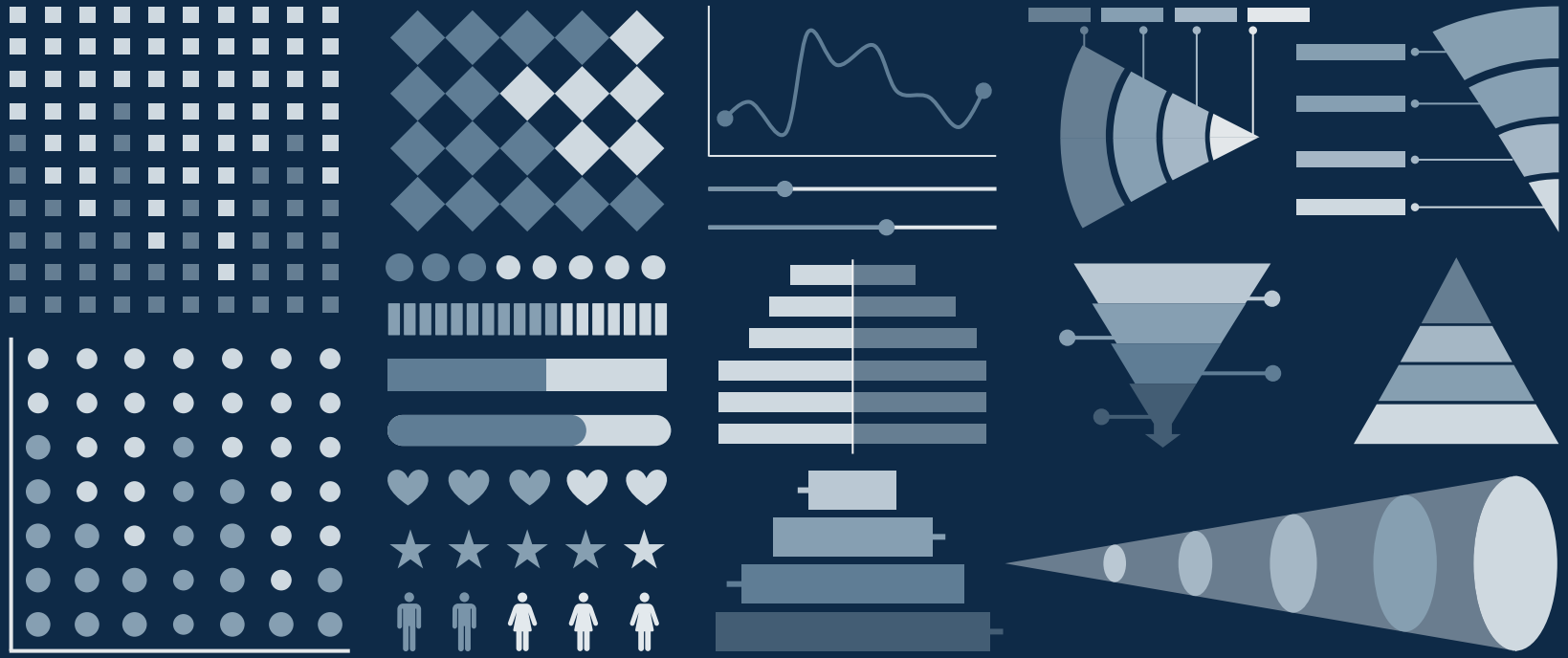

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