SOLID

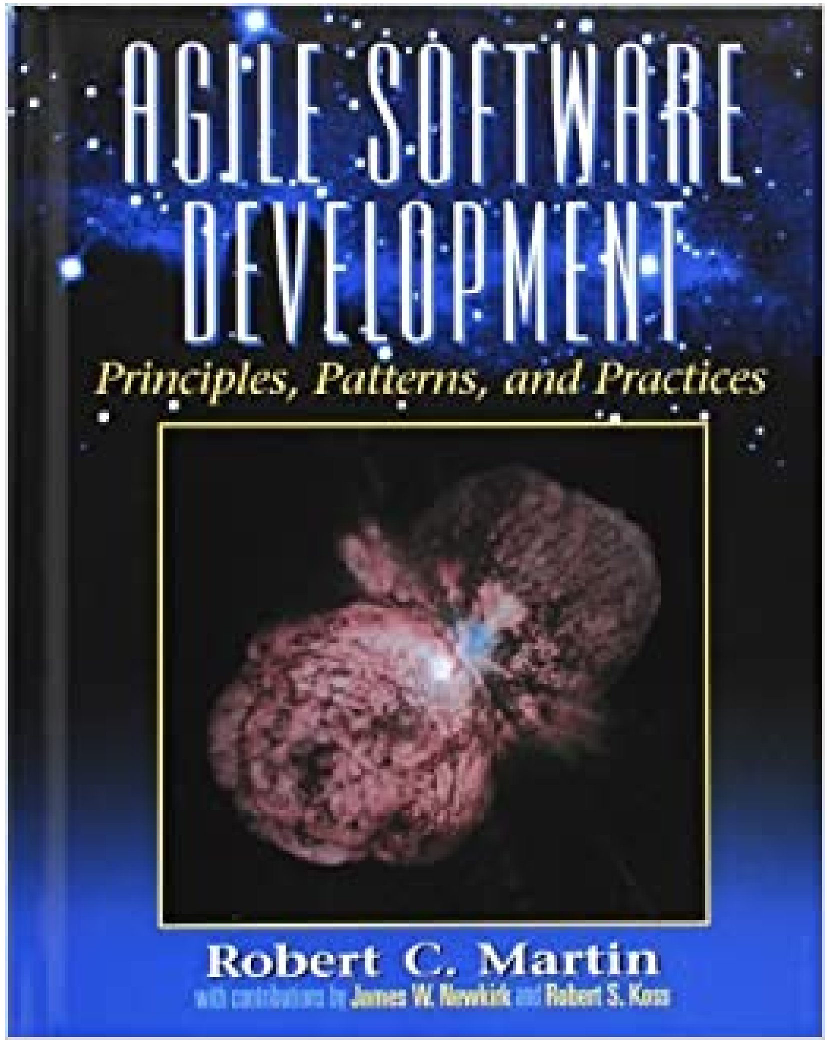
Liskov Substitution Principle (LSP)

Liskov Substitution Principle

> ***"Functions that use pointers or references to base classes must be able to use objects of derived classes without knowing it."***
> [Robert C. Martin]

Why?

- Increase of overall **Robustness**
- Increase of Maintainability
- Decrease of Rigidity


AGILE SOFTWARE DEVELOPMENT
Principles, Patterns, and Practices
Robert C. Martin
with contributions by James W. Newkirk and Robert S. Koss

Liskov Substitution Principle

> ***"If for each object o_1 of type S ther is an object o_2 of type T such that for all programs P defined in terms of T, the bahavior of p is unchanged when o_1 is substituted for o_2, then S is a subtype of T."*** [Barbara Liskov]

Liskov, Barbara. *Data Abstraction and Hierarchy*. SIGPLAN Notices, 23,5 (May 1988)

> ***"Subtype Requirement: Let $\phi(x)$ be a property provable about objects x of type T. Then $\phi(y)$ shoud be true for objects y of type S where S is a subtype of T."***
> [Barbara Liskov, Jeannette M. Wing]

Barbara Liskov, Jeannette M. Wing: *A Behavioral Notion of Subtyping*. ACM Trans. Program. Lang. Syst. 16(6): 1811-1841 (1994)

LSP In A Nutshell

Subtypes must preserve behavior of their supertypes.

The Circle-Ellipse Problem

Also called *Square–Rectangle Problem*. See more on this topic on Wikipedia.

Illustrates problems arising from use of *Subtype Polymorphism* in object-oriented design.

A simple question:

Circles are Ellipses, right?

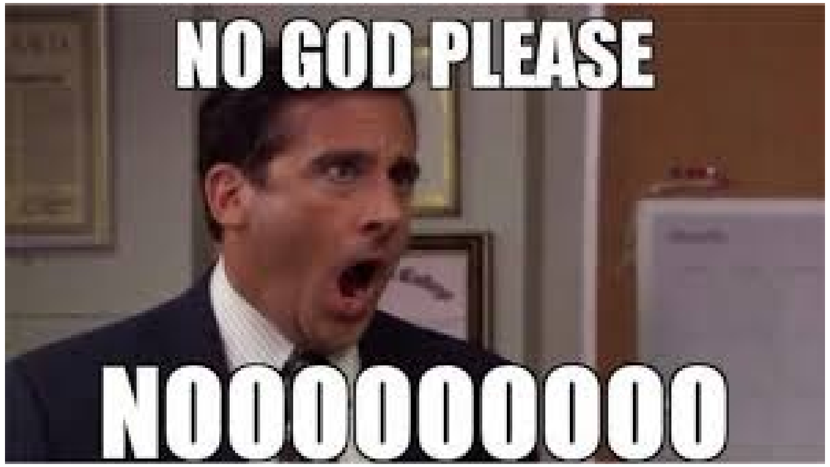
FYI: *Subtype Polymorphism* is the fancy name of Inheritence, a key technique for achieving Open/Closed systems, see *Open/Closed Principle*.

Are Circles Ellipses?

Well Trained Mathematician

Are Circles Ellipses?

Experienced Software Engineer



Why not?

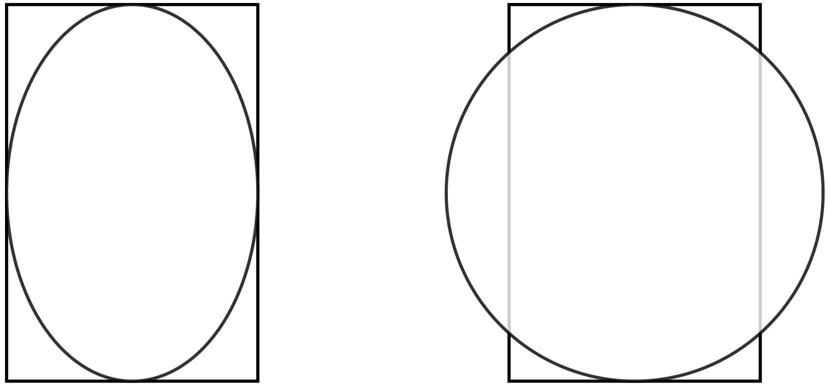
Of cource, circles are ellipses... from a geometric perspective.
But not every model of a circle should also be a model of an ellipse... from an OO perspective.

```
class Ellipse
{
    public uint Width { get; set; }
    public uint Height { get; set; }
    ...
}
class Circle : Ellipse
{
    public override uint Width
    {
        get => base.Width;
        set => { base.Width = value; base.Height = value; }
    }
    public override uint Height
    {
        get => base.Height;
        set => { base.Width = value; base.Height = value; }
    }
    ...
}
```

Why not?

```
void FitIntoRectangle(Ellipse ellipse, Rectangle rectangle)
{
    ellipse.Width = rectangle.Width;
    ellipse.Height = rectangle.Height;
    ellipse.Draw();
}

FitIntoRectangle(new Ellipse(), rectangle);
FitIntoRectangle(new Circle(), rectangle);
```



A **mutable** ellipse class makes the promise that width and height can be adjusted **independently**.

A derived circle breaks that promise by overwriting setters in order to keep geometric properties intact.

This doesn't work that well in the world of OO -.-

Other Example: "Exceptional" LSP Violation

```
class GiroAccount
{
    public double Balance { get; protected set; }
    public void Withdraw(double withdrawal)
    {
        Balance -= withdrawal;
    }
}
class DebtProtectedGiroAccount : GiroAccount
{
    public override void Withdraw(double withdrawal)
    {
        if (Balance - withdrawal < 0)
        {
            throw new InvalidOperationException();
        }
        base.Withdraw(withdrawal);
    }
}
```

Obviosly this breaks the promise of "not throwing (unexpected) exceptions" ;-)

The Circle-Ellipse Problem & Modeling Inheritence

- We think of inheritence as an ***IS-A*** relatioinship:
  - A circle IS-A ellipse
  - A square IS-A rectangle
- However, we tend to only condider "syntactic" traits:
  - Major/Minor Axes
  - Right Angles
  - Width/Height
- This can be problematic when mutations are possible:
  - See Circle-Ellipse Problem

The Circle-Ellipse Problem & Modeling Inheritence

- Instead, we should think of inhertience as ***BEHAVES-LIKE***
  - Software is about behavior
    Notably behavior desired by stakeholders
  - Inheritence does not only impose a "syntactic" contract it also imposes a "semantic" contract

Strategies against LSP Violations

Strategy 1: Design by Contract

Every operation has invariants, pre- and postconditions

$$\{P\}S\{Q\}$$

- Preconditions cannot be strenghened by a subtype
- Postconditions cannot be weakened by a subtype
- Invariants must be preserved by a subtype

Each subtype has to pass all tests of its supertype.

Further Reading on Desigin by Contract:
Bertrand Meyer. 1995. *Object-oriented software construction*, New York: Prentice Hall.

Strategies against LSP Violations

Strategy 2: Use Interfaces as much as possible

- Only use interfaces for polymorphism

Interfaces only impose syntactic contracts which makes LSP violations more or less impossible, since no behavior is really promised.

Downside

May require additional work, since no behavior is promised, e.g. not throwing exceptions.

Avoiding something under all costs is a sure way to develop a phobia for it ;-)

Thanks!