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**Assignment 2: Generics in RUST**

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**Rust Generics**

Generics is the topic of generalizing types and functionalities to broader cases. Generics is useful as it helps reduce duplicated code. However, using generics requires taking great care to specify over which types a generic type is actually considered valid. The simplest and most common use of generics is for type parameters. For example, defining a generic function named `myFunction` that takes an argument `T` of any type:

```
fn myFunction<T>(arg: T) { ... }
```

Although types in Rust are erased, generics are also reified. Consider the following code:

```
struct Bag<T> {  
    t: T,  
}  
  
fn main() {  
    let b = Bag { t: 42 };  
}
```

A `Bag<u8>` is not the same type as a `Bag<u32>`. Although it implements the same methods, it has a different size.

**Question 1:** Rewrite the `Bag` struct to hold an array of 3 items of type `T`.

**Question 2:** Write a function named `BagSize` that takes a `Bag` as an input and returns the size of a `Bag`.

Test your function with the following code:

```
let b1 = Bag {items: [1u8, 2u8, 3u8], };  
let b2 = Bag {items: [1u32, 2u32, 3u32], };
```

The code should give the following output:

```
size of First Bag = 3 bytes  
size of Second Bag = 12 bytes
```

**Question 3:** Rewrite the code for `b1` and `b2` without using any generics to produce the same output. [Hint: you will have to duplicate a lot of code]

However, monomorphization (<https://en.wikipedia.org/wiki/Monomorphism>) increases binary size, which is considered as its negative aspect. For example, if the `Bag` struct defined above has a lot of methods which uses a lot of different `T`s, this will result in creating a lot of variants. Imagine if we have multiple generic types!

**Question 4:** Consider the following code:

```
let vec1 = vec![12, 32, 13];
let vec2 = vec![44, 55, 16];
{ let vec1_iter = vec1.iter(); }
{let vec_chained = vec1.iter().chain(vec2.iter());}
{ let vec1_2=vec![vec1, vec2];
  let vec_flattened = vec1_2.iter().flatten(); }
```

Similar to Question2, report the sizes of `vec1_iter`, `vec_chained`, and `vec_flattened`.

**Question 5:** Run the code implemented in Question 4 but after boxing (<https://doc.rust-lang.org/std/boxed/struct.Box.html>) all the iterators. Again, report the sizes of `vec1_iter`, `vec_chained`, and `vec_flattened`.

**Question 6:** Explain the results obtained in Question 4 and 5 while illustrating the contents of both the stack and the heap in each case. [i.e., How does Rust model the iterators in each case?]

**Question 7:** What is polymorphism? Does Rust support polymorphism?

## Working with the Compiler Explorer

Now, let's explore one advantage of monomorphization. Since, in this case, the compiler knows the instantiated types ahead of time, this generates a lot of opportunities for optimizing code. Consider the following code:

```
fn equal<T>(x: T, y: T) -> bool
where T: PartialEq,
{
    x == y
}
fn compare(x: &str, y: &str) {
    equal(x, y);
    equal(x.len(), y.len());
}
pub fn main() {
    let mut i = std::env::args();
    let (x, y) = (i.next().unwrap(), i.next().unwrap());
    compare(&x, &y);
}
```

**Question 8:** Analyze the code using the compiler explorer (<https://godbolt.org/>) and report how many times the function `equal` has been called (Please mention the lines numbers).

**Question 9:** Now, use the optimization flag `-O` and recompile the code. How many times has the function `equal` been called? Explain what happened.