

Spring Professional Exam Tutorial v5.0

Environment Setup

Tools Used

- ▶ **JDK 11.0.2**
<https://www.oracle.com/technetwork/java/javase/downloads/jdk11-downloads-5066655.html>
- ▶ **Maven 3.6.1**
<https://www-eu.apache.org/dist/maven/maven-3/3.6.1/binaries/>
- ▶ **IntelliJ IDEA**
<https://www.jetbrains.com/idea/download/>

Environment Validation - JDK

► JDK Installation Validation

```
> echo %JAVA_HOME%
```

```
C:\Java\jdk-11.0.2
```

```
> java -version
```

```
java version "11.0.2" 2019-01-15 LTS
```

```
Java(TM) SE Runtime Environment 18.9 (build 11.0.2+9-LTS)
```

```
Java HotSpot(TM) 64-Bit Server VM 18.9 (build 11.0.2+9-LTS, mixed mode)
```

```
> javac -version
```

```
javac 11.0.2
```

Environment Validation - Maven

► Maven Installation Validation

```
> echo %MAVEN_HOME%
```

```
C:\apache-maven-3.6.1
```

```
> mvn -version
```

```
Apache Maven 3.6.1 (d66c9c0b3152b2e69ee9bac180bb8fcc8e6af555;  
2019-04-04T21:00:29+02:00)
```

```
Maven home: C:\apache-maven-3.6.1\bin\..
```

```
Java version: 11.0.2, vendor: Oracle Corporation, runtime:  
C:\Java\jdk-11.0.2
```

```
Default locale: en_US, platform encoding: Cp1250
```

```
OS name: "windows 10", version: "10.0", arch: "amd64", family:  
"windows"
```

Environment Validation - Compile all Examples and Run

Environment Validation Example

- ▶ Download & Extract Course Examples

- ▶ Compile all examples

```
> mvn clean install
```

- ▶ Validate that `[INFO] BUILD SUCCESS` is visible on the screen

- ▶ Go to `module01-environment-validation`

- ▶ Run the example

```
> mvn exec:java
```

- ▶ Validate that `Hello From Spring Framework` is visible on the screen

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Question 01

Question 01 - What is dependency injection and what are the advantages?

Dependency Injection is a technique of creating software in which objects do not create their dependencies on itself, instead objects declare dependencies that they need and it is external object job or framework job to provide concrete dependencies to objects.

Types of Dependency Injection:

- ▶ Constructor injection
- ▶ Setter injection
- ▶ Interface injection

Advantages of using dependency injection is:

- ▶ Increases code reusability
- ▶ Increases code readability
- ▶ Increases code maintainability
- ▶ Increases code testability
- ▶ Reduces coupling
- ▶ Increases cohesion

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Question 02

Question 02 - What is a pattern? What is an anti-pattern? Is dependency injection a pattern?

A Software Design Pattern is a reusable solution to often, commonly occurring problem in software design. It is a high level description on how to solve the problem, that can be used in many different situations. Design patterns often represent best practices that developers can use to solve common problems.

Some examples of commonly used design patterns from GoF Design Patterns:

- ▶ Factory Method
- ▶ Builder
- ▶ Template Method
- ▶ Strategy
- ▶ Observer
- ▶ Visitor
- ▶ Facade
- ▶ Composite

Dependency Injection is a pattern that solves problem of flexible dependencies creation.

Question 02 - What is a pattern? What is an anti-pattern? Is dependency injection a pattern?

Anti-pattern is ineffective and counter-productive solution to often occurring problem.

Examples of Anti-patterns in Object Oriented Programming:

- ▶ God Object
- ▶ Sequential coupling
- ▶ Circular dependency
- ▶ Constant interface

God Object:

huge class, lots of responsibilities, hard to test, hard to maintain, can't tell what its lifecycle, hard to reason about it. Each object should follow its unique and small responsibility.

Sequential Coupling:

One object invoking other objects method and these methods must be invoked in specific order different order of invocation will result in NPE or we get unexpected behaviour

Circular dependency:

Module A dependent on module B and module B is dependent on module C and module C dependent on module A. Issue: no way to compile the code.

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Question 03

Question 03 - What is an interface and what are the advantages of making use of them in Java? Why are they recommended for Spring beans?

OOP Definition - An interface is a description of actions that object can do, it is a way to enforce actions on object that implements the interface

Java Definition - An interface is a reference type, which contains collections of abstract method. Class that implements the interface, must implement all methods from this interface, or it needs to declare methods as abstract if object does not know how to implement specified method. Java Interface may contain also:

- ▶ Constants
- ▶ Default Methods (Java 8)
- ▶ Static methods
- ▶ Nested types

Question 03 - What is an interface and what are the advantages of making use of them in Java? Why are they recommended for Spring beans? (cont.)

Advantages of using interfaces in Java:

- ▶ Allows decoupling between contract and its implementation
- ▶ Allows declaring contract between callee and caller
- ▶ Increases interchangeability
- ▶ Increases testability

Advantages of using interfaces in Spring:

- ▶ Allows for use of JDK Dynamic Proxy
- ▶ Allows implementation hiding
- ▶ Allows to easily switch beans

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Question 04

Question 04 - What is meant by “application-context?”

Application Context is a central part of Spring application. It holds bean definitions and contains registry of application components. It allows you to retrieve assembled and configured beans.

Application Context:

- ▶ Initiates Beans
- ▶ Configures Beans
- ▶ Assembles Beans
- ▶ Manages Beans Lifecycle
- ▶ Is a Bean Factory
- ▶ Is a Resource Loader
- ▶ Has ability to push events to registered even listeners
- ▶ Exposes Environment which allows to resolve properties

Common Application Context types:

- ▶ AnnotationConfigApplicationContext
- ▶ AnnotationConfigWebApplicationContext
- ▶ ClassPathXmlApplicationContext
- ▶ FileSystemXmlApplicationContext
- ▶ XmlWebApplicationContext

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Question 05

Question 05 - What is the concept of a “container” and what is its lifecycle?

Container is an execution environment which provides additional technical services for your code to use. Usually containers use IoC technique, that allows you to focus on creating business aspect of the code, while technical aspects like communication details (HTTP, REST, SOAP) are provided by execution environment.

Spring provides a container for beans. It manages lifecycle of the beans and also provides additional services through usage of Application Context.

Question 05 - What is the concept of a “container” and what is its lifecycle? (cont.)

Spring Container Lifecycle:

1. Application is started.
2. Spring container is created.
3. Containers reads configuration.
4. Beans definitions are created from configuration.
5. BeanFactoryPostProcessors are processing bean definitions.
6. Instances of Spring Beans are created.
7. Spring Beans are configured and assembled - resolve property values and inject dependencies.
8. BeanPostProcessors are called.
9. Application Runs.
10. Application gets shutdown.
11. Spring Context is closed.
12. Destruction callbacks are invoked.

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Question 06

Question 06 - How are you going to create a new instance of an ApplicationContext?

Non-Web Applications:

- ▶ AnnotationConfigApplicationContext
- ▶ ClassPathXmlApplicationContext
- ▶ FileSystemXmlApplicationContext

Web Applications:

- ▶ Servlet 2 - web.xml, ContextLoaderListener, DispatcherServlet
- ▶ Servlet 3 - XmlWebApplicationContext
- ▶ Servlet 3 - AnnotationConfigWebApplicationContext

Spring Boot:

- ▶ SpringBootConsoleApplication - CommandLineRunner
- ▶ SpringBootWebApplication - Embedded Tomcat

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Question 07

Question 07 - Can you describe the lifecycle of a Spring Bean in an ApplicationContext?

Context is Created:

1. Beans Definitions are created based on Spring Bean Configuration.
2. BeanFactoryPostProcessors are invoked.

Bean is Created:

1. Instance of Bean is Created.
2. Properties and Dependencies are set.
3. BeanPostProcessor::postProcessBeforeInitialization gets called.
4. @PostConstruct method gets called.
5. InitializingBean::afterPropertiesSet method gets called.
6. @Bean(initMethod) method gets called
7. BeanPostProcessor::postProcessAfterInitialization gets called.

Bean is Ready to use.

Bean is Destroyed:

1. @PreDestroy method gets called.
2. DisposableBean::destroy method gets called.
3. @Bean(destroyMethod) method gets called.

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Question 08

Question 08 - How are you going to create an ApplicationContext in an integration test?

- ▶ Make sure that you have spring-test dependency added:

```
<dependency>
  <groupId>org.springframework</groupId>
  <artifactId>spring-test</artifactId>
  <version>5.1.6.RELEASE</version>
  <scope>test</scope>
</dependency>
```

- ▶ Add Spring Runner to your test

```
@RunWith(SpringRunner.class)
```

- ▶ Add Context Configuration to your test

```
@ContextConfiguration(classes = ApplicationConfiguration.class)
```


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Question 09

Question 09 - What is the preferred way to close an application context? Does Spring Boot do this for you?

- ▶ Standalone Non-Web Applications
 - ▶ Register Shutdown hook by calling `ConfigurableApplicationContext#registerShutdownHook` - Recommended way
 - ▶ Call `ConfigurableApplicationContext#close`
- ▶ Web Application
 - ▶ `ContextLoaderListener` will `automatically close context` when web container will stop web application
- ▶ Spring Boot
 - ▶ Application Context will be `automatically closed`
 - ▶ Shutdown hook will be automatically registered
 - ▶ `ContextLoaderListener` applies to Spring Boot Web Applications as well

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Question 10

Question 10 - Can you describe: Dependency injection using Java configuration? Dependency injection using annotations (@Component, @Autowired)? Component scanning, Stereotypes and Meta-Annotations? Scopes for Spring beans? What is the default scope?

Dependency Injection using Java Configuration

When using Dependency Injection using Java Configuration you need to explicitly define all your beans and you need to use @Autowired on @Bean method level to inject dependencies.

```
@Configuration
public class ApplicationConfiguration {
    @Bean
    @Autowired
    public SpringBean1 springBean1(SpringBean2 springBean2, SpringBean3 springBean3) {
        return new SpringBean1(springBean2, springBean3);
    }

    @Bean
    public SpringBean2 springBean2() {
        return new SpringBean2();
    }

    @Bean
    public SpringBean3 springBean3() {
        return new SpringBean3();
    }
}
```

Question 10 - Can you describe: Dependency injection using Java configuration? Dependency injection using annotations (@Component, @Autowired)? Component scanning, Stereotypes and Meta-Annotations? Scopes for Spring beans? What is the default scope? (cont.)

Dependency Injection using Annotations

- Create classes annotated with `@Component` annotations

```
@Component
public class SpringBean1
```

```
@Component
public class SpringBean2
```

```
@Component
public class SpringBean3
```

- Define dependencies when required

```
@Autowired
private SpringBean2 springBean2;
@Autowired
private SpringBean3 springBean3;
```

- Create Configuration with Component Scanning Enabled

```
@ComponentScan
public class ApplicationConfiguration {
}
```

Question 10 - Can you describe: Dependency injection using Java configuration? Dependency injection using annotations (@Component, @Autowired)? Component scanning, Stereotypes and Meta-Annotations? Scopes for Spring beans? What is the default scope? (cont.)

► Component Scanning

Process in which Spring is scanning Classpath in search for classes annotated with stereotypes annotations (@Component, @Repository, @Service, @Controller, ...) and based on those creates beans definitions.

► Simple component scanning within Configuration package and all subpackages

```
@ComponentScan
public class ApplicationConfiguration {
}
```

► Advanced Component Scanning Rules

```
@ComponentScan(
    basePackages = "com.spring.professional.exam.tutorial.module01.question10.annotations.beans",
    //basePackageClasses = SpringBean1.class,
    includeFilters = @ComponentScan.Filter(type = FilterType.REGEX, pattern = ".*Bean.*"),
    excludeFilters = @ComponentScan.Filter(type = FilterType.REGEX, pattern = ".*Bean1.*")
)
public class ApplicationConfigurationAdvanced {
}
```

Question 10 - Can you describe: Dependency injection using Java configuration? Dependency injection using annotations (@Component, @Autowired)? Component scanning, Stereotypes and Meta-Annotations? Scopes for Spring beans? What is the default scope? (cont.)

► Stereotypes - Definition

Stereotypes are annotations applied to classes to describe role which will be performed by this class. Spring discovers classes annotated by stereotypes and creates bean definitions based on those types.

► Types of stereotypes

- **Component** - generic component in the system, root stereotype, candidate for autoscanning
- **Service** - class will contain business logic
- **Repository** - class is a data repository (used for data access objects, persistence)
- **Controller** - class is a controller, usually a web controller (used with @RequestMapping)

Question 10 - Can you describe: Dependency injection using Java configuration? Dependency injection using annotations (@Component, @Autowired)? Component scanning, Stereotypes and Meta-Annotations? Scopes for Spring beans? What is the default scope? (cont.)

► Meta-Annotations

Meta-annotations are annotations that can be used to create new annotations.

► Example of Meta-Annotation

@RestController annotation is using @Controller and @ResponseBody to define its behavior

```
@Target({ElementType.TYPE})
@Retention(RetentionPolicy.RUNTIME)
@Documented
@Controller
@ResponseBody
public @interface RestController {
    @AliasFor(
        annotation = Controller.class
    )
    String value() default "";
}
```


Question 10 - Can you describe: Dependency injection using Java configuration? Dependency injection using annotations (@Component, @Autowired)? Component scanning, Stereotypes and Meta-Annotations? Scopes for Spring beans? What is the default scope? (cont.)

► Scopes of Spring Beans

Scope	Description
Singleton	Single Bean per Spring Container - Default
Prototype	<u>New Instance each time Bean is Requested</u>
Request	New Instance <u>per each HTTP Request</u>
Session	New Instance per each <u>HTTP Session</u>
Application	One Instance per each ServletContext
Websocket	One Instance per each WebSocket

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Question 11

Question 11 - Are beans lazily or eagerly instantiated by default? How do you alter this behavior?

Lazy and Eager Instance Creation vs Scope Type:

- ▶ Singleton Beans are eagerly instantiated by default
- ▶ Prototype Beans are lazily instantiated by default (instance is created when bean is requested)
 - ▶ ...however, if Singleton Bean has dependency on Prototype Bean, then Prototype Bean Instance will be created eagerly to satisfy dependencies for Singleton Bean

Altering Behavior:

- ▶ You can change default behavior for all beans by @ComponentScan annotation

```
@ComponentScan(lazyInit = true)
```

- ▶ Setting lazyInit to true, will make all beans lazy, even Singleton Beans
- ▶ Setting lazyInit to false (default), will create Singleton Beans Eagerly and Prototype Beans Lazily
- ▶ You can also change default behavior by using @Lazy annotation:
 - ▶ @Lazy annotation takes one parameter - Whether lazy initialization should occur
 - ▶ By default @Lazy is used to mark bean as lazily instantiated
 - ▶ You can use @Lazy(false) to force Eager Instantiation - use case for @ComponentScan(lazyInit = true) when some beans always needs to be instantiated eagerly
- ▶ @Lazy can be applied to:
 - ▶ Classed annotated with @Component - makes bean Lazy or as specified by @Lazy parameter
 - ▶ Classes annotated with @Configuration annotation - make all beans provided by configuration lazy or as specified by @Lazy parameter
 - ▶ Method annotated with @Bean annotation - makes bean created by method Lazy or as specified by @Lazy parameter

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Question 12

Question 12 - What is a property source? How would you use `@PropertySource`?

`PropertySource` is Spring Abstraction on Environment Key-Value pairs, which can come from:

- ▶ JVM Properties
- ▶ System Environmental Variables
- ▶ JNDI Properties
- ▶ Servlet Parameters
- ▶ Properties File Located on Filesystem
- ▶ **Properties File Located on Classpath**

You read properties with usage of `@PropertySource` or `@PropertySources` annotation:

```
@PropertySources({
    @PropertySource("file:${app-home}/app-db.properties"),
    @PropertySource("classpath:/app-defaults.properties")
})
```

You access properties with usage of `@Value` annotation:

```
@Value("${db.host}")
private String dbHost;
```

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Question 13

Question 13 - What is a BeanFactoryPostProcessor and what is it used for? When is it invoked? Why would you define a static @Bean method? What is a PropertySourcesPlaceholderConfigurer used for?

BeanFactoryPostProcessor is an interface that contains single method postProcessBeanFactory, implementing it allows you to create logic that will modify Spring Bean Metadata before any Bean is created. BeanFactoryPostProcessor does not create any beans, however it can access and alter Metadata that is used later to create Beans.

BeanFactoryPostProcessor is invoked after Spring will read or discover Bean Definitions, but before any Spring Bean is created.

Because BeanFactoryPostProcessor is also a Spring Bean, but a special kind of Bean that should be invoked before other types of beans get created, Spring needs to have ability to create it before any other beans. This is why BeanFactoryPostProcessors needs to be registered from static method level.

```
@Bean
public static CustomBeanFactoryPostProcessor customerBeanFactoryPostProcessor() {
    return new CustomBeanFactoryPostProcessor();
}
```

PropertySourcesPlaceholderConfigurer is a BeanFactoryPostProcessor that is used to resolve properties placeholder in Spring Beans on fields annotated with @Value("\${property_name}").

```
@Value("${app.env}")
private String appEnv;
@Value("${app.env.id}")
private String appEnvId;
```

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Question 14

Question 14 - What is a BeanPostProcessor and how is it different to a BeanFactoryPostProcessor? What do they do?

When are they called? What is an initialization method and how is it declared on a Spring bean? What is a destroy method, how is it declared and when is it called?

Consider how you enable JSR-250 annotations like @PostConstruct and @PreDestroy? When/how will they get called?

How else can you define an initialization or destruction method for a Spring bean?

What is a BeanPostProcessor and how is it different to a BeanFactoryPostProcessor? What do they do? When are they called?

BeanPostProcessor is an interface that allows you to create extensions to Spring Framework that will modify Spring Beans objects during initialization. This interface contains two methods:

- ▶ `postProcessBeforeInitialization`
- ▶ `postProcessAfterInitialization`

Implementing those methods allows you to modify created and assembled bean objects or even switch object that will represent the bean.

Main difference compared to BeanFactoryPostProcessor is that BeanFactoryPostProcessor works with Bean Definitions while BeanPostProcessor works with Bean Objects.

BeanFactoryPostProcessor and BeanPostProcessor in Spring Container Lifecycle

1. Beans Definitions are created based on Spring Bean Configuration.
2. `BeanFactoryPostProcessors` are invoked.
3. Instance of Bean is Created.
4. Properties and Dependencies are set.
5. `BeanPostProcessor::postProcessBeforeInitialization` gets called.
6. `@PostConstruct` method gets called.
7. `InitializingBean::afterPropertiesSet` method gets called.
8. `@Bean(initMethod)` method gets called
9. `BeanPostProcessor::postProcessAfterInitialization` gets called.

What is a BeanPostProcessor and how is it different to a BeanFactoryPostProcessor? What do they do? When are they called? (cont.)

Recommended way to define BeanPostProcessor is through static @Bean method in Application Configuration. This is because BeanPostProcessor should be created early, before other Beans Objects are ready.

```
@Bean
public static CustomBeanPostProcessor customBeanPostProcessor() {
    return new CustomBeanPostProcessor();
}
```

It is also possible to create BeanPostProcessor through regular registration in Application Configuration or through Component Scanning and @Component annotation, however because in that case bean can be created late in processes, recommended way is options provided above.

What is an initialization method and how is it declared on a Spring bean?

Initialization method is a method that you can write for Spring Bean if you need to perform some initialization code that depends on properties and/or dependencies injected into Spring Bean.

You can declare Initialization method in three ways:

- ▶ Create method in Spring Bean annotated with `@PostConstruct`
- ▶ Implement `InitializingBean::afterPropertiesSet`
- ▶ Create Bean in Configuration class with `@Bean` method and use `@Bean(initMethod)`

What is a destroy method, how is it declared?

Destroy method is a method in Spring Bean that you can use to implement any cleanup logic for resources used by the Bean. Method will be called when Spring Bean will be taken out of use, this is usually happening when Spring Context is closed.

You can declare destroy method in following ways:

- ▶ Create method annotated with `@PreDestroy` annotation
- ▶ Implement `DisposableBean::destroy`
- ▶ Create Bean in Configuration class with `@Bean` method and use `@Bean(destroyMethod)`

Consider how you enable JSR-250 annotations like `@PostConstruct` and `@PreDestroy`?

When using `AnnotationConfigApplicationContext` support for `@PostConstruct` and `@PreDestroy` is added automatically.

Those annotations are handled by `CommonAnnotationBeanPostProcessor` which is automatically registered by `AnnotationConfigApplicationContext`.

When/how will they (initialization, destroy methods) get called?

Context is Created:

1. Beans Definitions are created based on Spring Bean Configuration.
2. BeanFactoryPostProcessors are invoked.

Bean is Created:

1. Instance of Bean is Created.
2. Properties and Dependencies are set.
3. BeanPostProcessor::postProcessBeforeInitialization gets called.
4. @PostConstruct method gets called.
5. InitializingBean::afterPropertiesSet method gets called.
6. @Bean(initMethod) method gets called
7. BeanPostProcessor::postProcessAfterInitialization gets called.

Bean is Ready to use.

Bean is Destroyed (usually when context is closed):

1. @PreDestroy method gets called.
2. DisposableBean::destroy method gets called.
3. @Bean(destroyMethod) method gets called.

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Question 15

Question 15 - What does component-scanning do?

► Component Scanning

Process in which Spring is scanning Classpath in search for classes annotated with stereotypes annotations (`@Component`, `@Repository`, `@Service`, `@Controller`, ...) and based on those creates beans definitions.

► Simple component scanning within Configuration package and all subpackages

```
@ComponentScan
public class ApplicationConfiguration {
}
```

► Advanced Component Scanning Rules

```
@ComponentScan(
    basePackages = "com.spring.professional.exam.tutorial.module01.question15.advanced.beans",
    includeFilters = @ComponentScan.Filter(type = FilterType.REGEX, pattern = ".*Bean"),
    excludeFilters = @ComponentScan.Filter(type = FilterType.REGEX, pattern = ".*(Controller|Service).*")
)
public class ApplicationConfiguration {
}
```

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Question 16

Question 16 - What is the behavior of the annotation @Autowired with regards to field injection, constructor injection and method injection?

`@Autowired` is an annotation that is processed by `AutowiredAnnotationBeanPostProcessor`, which can be put onto class constructor, field, setter method or config method. Using this annotation enables automatic Spring Dependency Resolution that is primary based on types.

`@Autowired` has a property `required` which can be used to tell Spring if dependency is required or optional. By default dependency is required. If `@Autowired` with required dependency is used on top of constructor or method that contains multiple arguments, then all arguments are considered required dependency unless argument is of type `Optional`, is marked as `Nullable`, or is marked as `@Autowired(required = false)`.

If `@Autowired` is used on top of `Collection` or `Map` then Spring will inject all beans matching the type into `Collection` and key-value pairs as `BeanName-Bean` into `Map`. Order of elements depends on usage of `@Order`, `@Priority` annotations and implementation of `Ordered` interface.

`@Autowired` uses following steps when resolving dependency:

1. Match exactly by type, if only one found, finish.
2. If multiple beans of same type found, check if any contains @Primary annotation, if yes, inject `@Primary` bean and finish.
3. If no exactly one match exists, check if @Qualifier exists for field, if yes use `@Qualifier` to find matching bean.
4. If still no exactly one bean found, narrow the search by using bean name.
5. If still no exactly one bean found, throw exception (`NoSuchBeanDefinitionException`, `NoUniqueBeanDefinitionException`, ...).

Question 16 - What is the behavior of the annotation @Autowired with regards to field injection, constructor injection and method injection?

@Autowired with field injection is used like this:

```
@Autowired
public DbRecordsReader recordsReader;
@Autowired
protected DbRecordsBackup recordsBackup;
@Autowired
private DbRecordsProcessor recordsProcessor;
@Autowired
DbRecordsWriter recordsWriter;
```

- ▶ Autowired fields can have any visibility level
- ▶ Injection is happening after Bean is created but before any init method (@PostConstruct, InitializingBean, @Bean(initMethod)) is called
- ▶ By default field is required, however you can use Optional, @Nullable or @Autowired(required = false) to indicate that field is not required.

Question 16 - What is the behavior of the annotation @Autowired with regards to field injection, constructor injection and method injection?

@Autowired can be used with constructor like this:

```
@Autowired
public RecordsService(DbRecordsReader recordsReader, DbRecordsProcessor recordsProcessor) {
    this.recordsReader = recordsReader;
    this.recordsProcessor = recordsProcessor;
}
```

Constructor can have any access modifier (public, protected, private, package-private).

If there is only one constructor in class, there is no need to use @Autowired on top of it, Spring will use this default constructor anyway and will inject dependencies into it.

If class defines multiple constructor, then you are obligated to use @Autowired to tell Spring which constructor should be used to create Spring Bean. If you will have a class with multiple constructor without any of constructor marked as @Autowired then Spring will throw NoSuchMethodException.

By default all arguments in constructor are required, however you can use Optional, @Nullable or @Autowired(required = false) to indicate that parameter is not required.

Question 16 - What is the behavior of the annotation @Autowired with regards to field injection, constructor injection and method injection?

@Autowired can be used with method injection like this:

```
@Autowired
public void setRecordsReader(DbRecordsReader recordsReader) {
    this.recordsReader = recordsReader;
}
```

@Autowired method can have any visibility level and also can contain multiple parameters. If method contains multiple parameters, then by default it is assumed that in @Autowired method all parameters are required. If Spring will be unable to resolve all dependencies for this method, `NoSuchBeanDefinitionException` or `NoUniqueBeanDefinitionException` will be thrown.

When using `@Autowired(required = false)` with method, it will be invoked only if Spring can resolve all parameters.

If you want Spring to invoke method only with arguments partially resolved, you need to use @Autowired method with parameter marked as `Optional`, `Nullable` or `@Autowired(required = false)` to indicate that this parameter is not required.

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Question 17



Question 17 - What do you have to do, if you would like to inject something into a private field? How does this impact testing?

Injection of dependency into private field can be done with `@Autowired` annotation:

```
@Autowired
private ReportWriter reportWriter;
```

Injection of property into private field can be done with `@Value` annotation:

```
@Value("${report.global.name}")
private String reportGlobalName;
```

Private Field cannot be accessed from outside of the class, to resolve this when writing Unit Test you can use following solutions:

- ▶ Use `SpringRunner` with `ContextConfiguration` and `@MockBean`
- ▶ Use `ReflectionTestUtils` to modify private fields
- ▶ Use `MockitoJUnitRunner` to inject mocks
- ▶ Use `@TestPropertySource` to inject test properties into private fields

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Question 18

Question 18 - How does the `@Qualifier` annotation complement the use of `@Autowired`?

`@Qualifier` annotation gives you additional control on which bean will be injected, when multiple beans of the same type are found. By adding additional information on which bean you want to inject, `@Qualifier` resolves issues with `NoUniqueBeanDefinitionException`.

You can use `@Qualifier` in three ways:

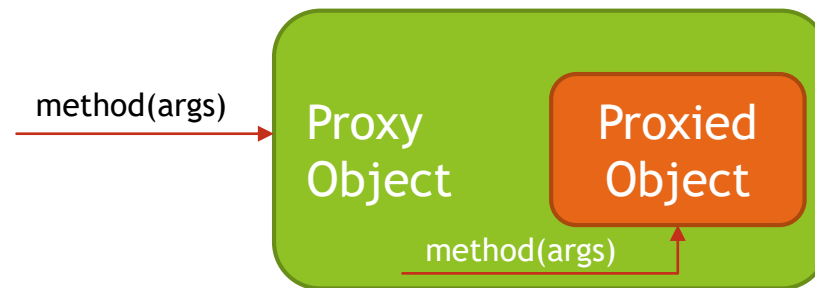
- ▶ At injection point with bean name as value
- ▶ At injection and bean definition point
- ▶ Custom Qualifier Annotation Definition

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Question 19

Question 19 - What is a proxy object and what are the two different types of proxies Spring can create? What are the limitations of these proxies (per type)? What is the power of a proxy object and where are the disadvantages?

Proxy Object is an object that adds additional logic on top of object that is being proxied without having to modify code of proxied object. Proxy object has the same public methods as object that is being proxied and it should be as much as possible indistinguishable from proxied object. When method is invoked on Proxy Object, additional code, usually before and after sections are invoked, also code from proxied object is invoked by Proxy Object.



Question 19 - What is a proxy object and what are the two different types of proxies Spring can create? What are the limitations of these proxies (per type)? What is the power of a proxy object and where are the disadvantages? (cont.)

Spring Framework supports two kind of proxies:

- ▶ JDK Dynamic Proxy - used by default if target object implements interface
- ▶ CGLIB Proxy - use when target does not implement any interface

Limitations of JDK Dynamic Proxy:

- ▶ Requires proxy object to implement the interface
- ▶ Only interface methods will be proxied
- ▶ No support for self-invocation

Limitations of CGLIB Proxy:

- ▶ Does not work for final classes
- ▶ Does not work for final methods
- ▶ No support for self-invocation

Question 19 - What is a proxy object and what are the two different types of proxies Spring can create? What are the limitations of these proxies (per type)? What is the power of a proxy object and where are the disadvantages? (cont.)

Proxy Advantages:

- ▶ Ability to change behavior of existing beans without changing original code
- ▶ Separation of concerns (logging, transactions, security, ...)

Proxy Disadvantages:

- ▶ May create code hard to debug
- ▶ Needs to use unchecked exception for exceptions not declared in original method
- ▶ May cause performance issues if before/after section in proxy code is using IO (Network, Disk)
- ▶ May cause unexpected equals operator (==) results since Proxy Object and Proxied Object are two different objects

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Question 20

Question 20 - What are the advantages of Java Config? What are the limitations?

Advantages of Java Config over XML Config:

- ▶ Compile-Time Feedback due to Type-checking
- ▶ Refactoring Tools for Java without special support/plugins work out of the box with Java Config (special support needed for XML Config)

Advantages of Java Config over Annotation Based Config:

- ▶ Separation of concerns - beans configuration is separated from beans implementation
- ▶ Technology agnostic - beans may not depend on concrete IoC/DI implementation - makes it easier to switch technology
- ▶ Ability to integrate Spring with external libraries
- ▶ More centralized location of bean list

Limitations of Java Config:

- ▶ Configuration class cannot be final
- ▶ Configuration class methods cannot be final
- ▶ All Beans have to be listed, for big applications, it might be a challenge compared to Component Scanning

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Question 21

Question 21 - What does the @Bean annotation do?

@Bean annotation is used in @Configuration class to inform Spring that instance of class returned by method annotated with @Bean will return bean that will be managed by Spring.

@Bean also allows you to:

- ▶ Specify init method - will be called after instance is created and assembled
- ▶ Specify destroy method - will be called when bean is discarded (usually when context is getting closed)
- ▶ Specify name for the bean - by default bean has name autogenerated based on method name, however this can be overridden
- ▶ Specify alias/aliases for the bean
- ▶ Specify if Bean should be used as candidate for injection into other beans - default true
- ▶ Configure Autowiring mode - by name or type (Deprecated since Spring 5.1)

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Question 22

Question 22 - What is the default bean id if you only use @Bean? How can you override this?

When using @Bean without specifying name or alias, default bean id will be created based on name of the method which was annotated with @Bean annotation.

```
@Bean
public SpringBean1 springBean1() {
    return new SpringBean1();
}
```

You can override this behavior by specifying name or aliases for the bean.

```
@Bean(name = "2ndSpringBean")
public SpringBean2 springBean2() {
    return new SpringBean2();
}

@Bean(name = {"3rdSpringBean", "thirdSpringBean"})
public SpringBean3 springBean3() {
    return new SpringBean3();
}
```

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Question 23

Question 23 - Why are you not allowed to annotate a final class with @Configuration? How do @Configuration annotated classes support singleton beans? Why can't @Bean methods be final either?

Class annotated with `@Configuration` cannot be final because Spring will use CGLIB to create a proxy for `@Configuration` class. CGLIB creates subclass for each class that is supposed to be proxied, however since final class cannot have subclass CGLIB will fail. This is also a reason why methods cannot be final, Spring needs to override methods from parent class for proxy to work correctly, however final method cannot be overridden, having such a method will make CGLIB fail.

If `@Configuration` class will be final or will have final method, Spring will throw `BeanDefinitionParsingException`.

Spring supports Singleton beans in `@Configuration` class by creating CGLIB proxy that intercepts calls to the method. Before method is executed from the proxied class, proxy intercept a call and checks if instance of the bean already exists, if instance of the bean exists, then call to method is not allowed and already existing instance is returned, if instance does not exists, then call is allowed, bean is created and instance is returned and saved for future reuse. To make method call interception CGLIB proxy needs to create subclass and also needs to override methods.

Easiest way to observe that calls to original `@Configuration` class are proxied is with usage of debugger or by printing stacktrace. When looking at stacktrace you will notice that class which serves beans is not original class written by you but it is different class, which name contains `$$EnhancerBySpringCGLIB`.

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Question 24

Question 24 - How do you configure profiles? What are possible use cases where they might be useful?

Spring Profiles are configured by:

- ▶ Specifying which beans are part of which profile
- ▶ Specifying which profiles are active

You can specify beans being part of profile in following ways:

- ▶ Use `@Profile` annotation at `@Component` class level - bean will be part of profile/profiles specified in annotation
- ▶ Use `@Profile` annotation at `@Configuration` class level - all beans from this configuration will be part of profile/profiles specified in annotation
- ▶ Use `@Profile` annotation at `@Bean` method of `@Configuration` class - instance of bean returned by this method will be part of profile/profiles specified in annotation
- ▶ Use `@Profile` annotation to define custom annotation - `@Component` / `@Configuration` / `@Bean` method annotated with custom annotation will be part of profile/profiles specified in annotation

If Bean does not have profile specified in any way, it will be created in every profile.
You can use '!' to specify in which profile bean should not be created.

You can activate profiles in following way:

- ▶ Programmatically with usage of `ConfigurableEnvironment`
- ▶ By using `spring.profiles.active` property
- ▶ On JUnit Test level by using `@ActiveProfiles` annotation
- ▶ In Spring Boot Programmatically by usage of `SpringApplicationBuilder`
- ▶ In Spring Boot by `application.properties` or on `yml` level

Question 24 - How do you configure profiles? What are possible use cases where they might be useful? (cont.)

Spring Profiles are useful in following cases:

- ▶ Changing Behavior of the system in Different Environments by changing set of Beans that are part of specific environments, for example prod, cert, dev
- ▶ Changing Behavior of the system for different customers
- ▶ Changing set of Beans used in Development Environment and also during Testing Execution
- ▶ Changing set of Beans in the system when monitoring or additional debugging capabilities should be turned on

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Question 25

Question 25 - Can you use @Bean together with @Profile?

Yes, @Bean annotation can be used together with @Profile inside class annotated with @Configuration annotation on top of method that returns instance of the bean.

If, method annotated with @Bean does not have @Profile, that means that this bean will exist in all profiles.

You can specify one, multiple profiles, or profile in which bean should not exist:

```
@Profile("database")
@Profile("!prod")
@Bean
@Profile({"database", "file"})
```

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Question 26

Question 26 - Can you use @Component together with @Profile?

Yes, @Profile annotation can be used together with @Component on top of class representing spring bean.

If, class annotated with @Component does not have @Profile, that means that this bean will exist in all profiles.

You can specify one, multiple profiles, or profile in which bean should not exist:

```
@Profile("database")
@Component
@Profile("!prod")
@Profile({"database", "file"})
```

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Question 27

Question 27 - How many profiles can you have?

Spring Framework does not specify any explicit limit on number of profiles, however since some of the classes in Framework, like `ActiveProfilesUtils` used by default implementation of `ActiveProfilesResolver` are using array to iterate over profiles, this enforces inexplicit limit that is equal to maximum number of elements in array that you can have in Java, which is `Integer.MAX_VALUE` - 2,147,483,647 ($2^{31} - 1$).

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Question 28

Question 28 - How do you inject scalar/literal values into Spring beans?

To inject scalar/literal values into Spring Beans, you need to use `@Value` annotation.

`@Value` annotation has one field value that accepts:

- ▶ Simple value
- ▶ Property reference
- ▶ SpEL String

`@Value` annotation can be used on top of:

- ▶ Field
- ▶ Constructor Parameter
- ▶ Method - all fields will have injected the same value
- ▶ Method parameter - Injection will not be performed automatically if `@Value` is not present on method level or if `@Autowired` is not present at method level
- ▶ Annotation type

Inside `@Value` you can specify:

- ▶ Simple value - `@Value("John"), @Value("true")`
- ▶ Reference a property - `@Value("${app.department.id}")`
- ▶ Perform SpEL inline computation - `@Value("#{ 'Wall Street' .toUpperCase() }"), @Value("#{ 5000 * 0.9 }"), @Value("#{ '${app.department.id}' .toUpperCase() }")`
- ▶ Inject values into array, list, set, map

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Question 29

Question 29 - What is @Value used for?

@Value is used for:

- ▶ Setting simple values of Spring Bean Fields, Method Parameters, Constructor Parameters
- ▶ Injecting property/environment values into Spring Bean Fields, Method Parameters, Constructor Parameters
- ▶ Injecting results of SpEL expressions into Spring Bean Fields, Method Parameters, Constructor Parameters
- ▶ Injecting values from other Spring Beans into Spring Bean Fields, Method Parameters, Constructor Parameters
- ▶ Injecting values into collections (arrays, lists, sets, maps) from literals, property/environment values, other Spring Beans
- ▶ Setting default values of Spring Bean Fields, Method Parameters, Constructor Parameters when referenced value is missing

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Question 30

Question 30 - What is Spring Expression Language (SpEL for short)?

Spring Expression Language (SpEL) is an expression language that allows you to query and manipulate objects graphs during the runtime. SpEL is used in different products across Spring portfolio.

SpEL can be used independently with usage of `ExpressionParser` and `EvaluationContext` or can be used on top of fields, method parameters, constructor arguments via `@Value` annotation `@Value("#{ ... }")`.

SpEL supported features:

- ▶ Literal expressions
- ▶ Boolean and relational operators
- ▶ Regular expressions
- ▶ Class expressions
- ▶ Accessing properties, arrays, lists, and maps
- ▶ Method invocation
- ▶ Relational operators
- ▶ Assignment
- ▶ Calling constructors
- ▶ Bean references
- ▶ Array construction
- ▶ Inline lists
- ▶ Inline maps
- ▶ Ternary operator
- ▶ Variables
- ▶ User-defined functions
- ▶ Collection projection
- ▶ Collection selection
- ▶ Templated expressions

Language Reference - <https://docs.spring.io/spring/docs/current/spring-framework-reference/core.html#expressions-language-ref>

Question 30 - What is Spring Expression Language (SpEL for short)? (cont.)

SpEL expressions are usually interpreted during runtime, this is good since it provides a lot of dynamic features. However, in some cases performance is more important than number of features available, for those cases Spring Framework 4.1 introduced possibility to compile expressions.

Compilation of Spring Expression is done by creating real Java Class that embodies expression, this results in much faster Expression Evaluation. Because during compilation, reference types of properties are unknown, Compiled Expressions are best to use when types of referenced types are not changing.

Compiler is turned off by default, you can turn it on by:

- ▶ Parser Configuration
- ▶ System Property - `spring.expression.compiler.mode`

Compiler can operation in three modes (`SpelCompilerMode`)

- ▶ Off - default
- ▶ Immediate - compile upon first expression interpretation
- ▶ Mixed - compiler dynamically switched between interpreted and compiled mode, compiled form is generated after few invocations, if exception will be thrown during compiled form evaluation, then fallback to interpreted form will occur, and then after few invocation compiler will switch to compiled mode again

Compiled Mode does not support following expressions:

- ▶ Expressions involving assignment
- ▶ Expressions relying on the conversion service
- ▶ Expressions using custom resolvers or accessors
- ▶ Expressions using selection or projection

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Question 31

Question 31 - What is the Environment abstraction in Spring?

Environment Abstraction is part of Spring Container that models two key aspect of application environment:

- ▶ Profiles
- ▶ Properties

Environment Abstraction is represent on code level by classes that implements `Environment` interface. This interface allows you to resolve properties and also to list profiles. You can receive reference to class that implements `Environment` by calling `EnvironmentCapable` class, implemented by `ApplicationContext`. Properties can also be retrieved by using `@Value("${...}")` annotation.

Environment Abstraction role in context of profiles is to determine which profiles are currently active, and which are activated by default.

Environment Abstraction role in context of properties is to provide convenient, standardized and generic service that allows to resolve properties and also to configure property sources. Properties may come from following sources:

- ▶ Properties Files
- ▶ JVM system properties
- ▶ System Environment Variables
- ▶ JNDI
- ▶ Servlet Config
- ▶ Servlet Context Parameters

Default property sources for standalone applications are configured in `StandardEnvironment`, which includes JVM system properties and System Environment Variables. When running Spring Application in Servlet Environment, property sources will be configured based on `StandardServletEnvironment`, which additionally includes Servlet Config and Servlet Context Parameters, optionally it might include `JndiPropertySource`.

To add additional properties files as property sources you can use `@PropertySource` annotation.

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Question 32

Question 32 - Where can properties in the environment come from - there are many sources for properties - check the documentation if not sure. Spring Boot adds even more.

Property Sources in Spring Application vary based on type of applications that is being executed:

- ▶ Standalone Application
- ▶ Servlet Container Application
- ▶ Spring Boot Application

Question 32 - Where can properties in the environment come from - there are many sources for properties - check the documentation if not sure. Spring Boot adds even more. (cont.)

Property Sources for Standalone Spring Framework Application:

- ▶ Properties Files
- ▶ JVM system properties
- ▶ System Environment Variables

Question 32 - Where can properties in the environment come from - there are many sources for properties - check the documentation if not sure. Spring Boot adds even more. (cont.)

Property Sources for Servlet Container Spring Framework Application:

- ▶ Properties Files
- ▶ JVM system properties
- ▶ System Environment Variables
- ▶ JNDI
- ▶ ServletConfig init parameters
- ▶ ServletContext init parameters

Question 32 - Where can properties in the environment come from - there are many sources for properties - check the documentation if not sure. Spring Boot adds even more. (cont.)

Property Sources for Spring Boot Application:

- ▶ Devtools properties from `~/.spring-boot-devtools.properties` (when devtools is active)
- ▶ `@TestPropertySource` annotations on tests
- ▶ `Properties` attribute in `@SpringBootTest` tests
- ▶ Command line arguments
- ▶ Properties from `SPRING_APPLICATION_JSON` property
- ▶ `ServletConfig` init parameters
- ▶ `ServletContext` init parameters
- ▶ JNDI attributes from `java:comp/env`
- ▶ JVM system properties
- ▶ System Environment Variables
- ▶ `RandomValuePropertySource` - `${random.*}`
- ▶ `application-{profile}.properties` and YAML variants - outside of jar
- ▶ `application-{profile}.properties` and YAML variants - inside jar
- ▶ `application.properties` and YAML variants - outside of jar
- ▶ `application.properties` and YAML variants - inside jar
- ▶ `@PropertySource` annotations on `@Configuration` classes
- ▶ Default properties - `SpringApplication.setDefaultProperties`

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Question 34

Question 34 - What is the difference between \$ and # in @Value expressions?

@Value annotation supports two types of expressions:

- ▶ Expressions starting with \$ - used to reference a property in Spring Environment Abstraction
- ▶ Expressions starting with # - SpEL expressions parsed and evaluated by SpEL