

CLOUD COMPUTING LAB

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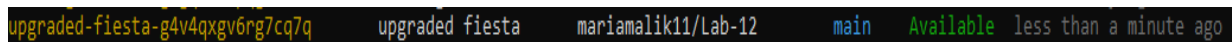
Submitted to: Sir Muhammad Shoaib

Class: 5B

LAB #11

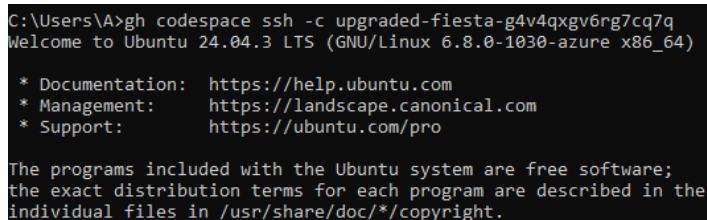
Task 0 Lab Setup (Codespace & GH CLI)

- taskA_codespace_create_and_list.png



```
upgraded-fiesta-g4v4qxgv6rg7cq7q    upgraded fiesta    mariamalik11/Lab-12    main    Available less than a minute ago
```

- taskA_codespace_ssh_connected.png



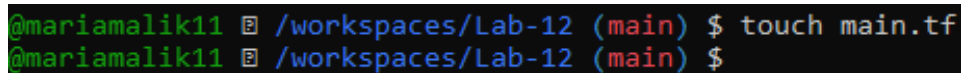
```
C:\Users\A>gh codespace ssh -c upgraded-fiesta-g4v4qxgv6rg7cq7q
Welcome to Ubuntu 24.04.3 LTS (GNU/Linux 6.8.0-1030-azure x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/pro

The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.
```

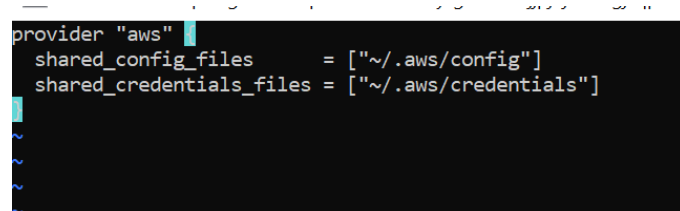
Task 1 — Provider & Basic variable (variable precedence)

- task1_touch_main_tf.png



```
@mariamalik11 /workspaces/Lab-12 (main) $ touch main.tf
@mariamalik11 /workspaces/Lab-12 (main) $
```

- task1_main_tf_provider.png



```
provider "aws" {
  shared_config_files = ["~/.aws/config"]
  shared_credentials_files = ["~/.aws/credentials"]
}
```

- task1_terraform_init.png

```

@mariamalik11 ~ /workspaces/Lab-12 (main) $ terraform init
Initializing the backend...
Initializing provider plugins...
- Reusing previous version of hashicorp/aws from the dependency lock file
- Using previously-installed hashicorp/aws v6.27.0
Terraform has made some changes to the provider dependency selections recorded
in the .terraform.lock.hcl file. Review those changes and commit them to your
version control system if they represent changes you intended to make.

Terraform has been successfully initialized!

You may now begin working with Terraform. Try running "terraform plan" to see
any changes that are required for your infrastructure. All Terraform commands
should now work.

If you ever set or change modules or backend configuration for Terraform,
rerun this command to reinitialize your working directory. If you forget, other
commands will detect it and remind you to do so if necessary.

```

- task1_variable_and_output_added.png

```

provider "aws" {
  shared_config_files      = ["~/.aws/config"]
  shared_credentials_files = ["~/.aws/credentials"]
}

variable "subnet_cidr_block" {
  type = string
}

output "subnet_cidr_block_output" {
  value = var.subnet_cidr_block
}

```

- task1_apply_prompt_for_var.png

```

@mariamalik11 ~ /workspaces/Lab-12 (main) $ terraform apply -auto-approve
var.subnet_cidr_block
Enter a value: 0.0.0.0/0

Changes to Outputs:
+ subnet_cidr_block_output = "0.0.0.0/0"

You can apply this plan to save these new output values to the Terraform state, without changing any real
infrastructure.

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:
subnet_cidr_block_output = "0.0.0.0/0"

```

- task1_apply_with_default.png

```

@mariamalik11 ~ /workspaces/Lab-12 (main) $ terraform apply -auto-approve

Changes to Outputs:
~ subnet_cidr_block_output = "0.0.0.0/0" -> "10.0.0.0/24"

You can apply this plan to save these new output values to the Terraform state, without changing any real
infrastructure.

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:
subnet_cidr_block_output = "10.0.0.0/24"

```

- task1_env_var_set_and_apply.png

```

@mariamalik11 ~ /workspaces/Lab-12 (main) $ export TF_VAR_subnet_cidr_block=10.0.20.0/24
@mariamalik11 ~ /workspaces/Lab-12 (main) $ terraform apply -auto-approve

Changes to Outputs:
~ subnet_cidr_block_output = "10.0.0.0/24" -> "10.0.20.0/24"

You can apply this plan to save these new output values to the Terraform state, without changing any real
infrastructure.

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:

```

- task1_terraform_tfvars_and_apply.png

```
@mariamalik11 @ /workspaces/Lab-12 (main) $ cat terraform.tfvars
subnet_cidr_block = "10.0.30.0/24"
@mariamalik11 @ /workspaces/Lab-12 (main) $ terraform apply -auto-approve

Changes to Outputs:
  ~ subnet_cidr_block_output = "10.0.20.0/24" -> "10.0.30.0/24"

You can apply this plan to save these new output values to the Terraform state, without changing any real
infrastructure.

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:
subnet_cidr_block_output = "10.0.30.0/24"
```

- task1_var_override_with_dash_var.png

```
@mariamalik11 @ /workspaces/Lab-12 (main) $ terraform apply -auto-approve -var "subnet_cidr_block=10.0.40.0/24"

Changes to Outputs:
  ~ subnet_cidr_block_output = "10.0.30.0/24" -> "10.0.40.0/24"

You can apply this plan to save these new output values to the Terraform state, without changing any real
infrastructure.

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:
subnet_cidr_block_output = "10.0.40.0/24"
```

- task1_printenv_tf_var_and_unset.png

```
@mariamalik11 @ /workspaces/Lab-12 (main) $ printenv | grep TF_VAR_
TF_VAR_subnet_cidr_block=10.0.20.0/24
@mariamalik11 @ /workspaces/Lab-12 (main) $ unset TF_VAR_subnet_cidr_block
@mariamalik11 @ /workspaces/Lab-12 (main) $ printenv | grep TF_VAR_
```

Task 2 — Variable validation & sensitive / ephemeral variables

- task2_subnet_variable_with_validation.png

```
output "subnet_cidr_block_output" {
  value = var.subnet_cidr_block
}
variable "subnet_cidr_block" {
  type        = string
  default     = ""
  description = "CIDR block to assign to the application subnet"
  sensitive   = false
  nullable    = false
  ephemeral   = false

  validation {
    condition     = can(regex("^[0-9]{1,3}\\.[0-9]{1,3}/[0-9]+$", var.subnet_cidr_block))
    error_message = "The subnet_cidr_block must be a valid CIDR notation string, such as 10.0.0.0/24."
  }
}
```

- task2_subnet_validation_error.png

```
@mariamalik11 @ /workspaces/Lab-12 (main) $ terraform apply -auto-approve -var
subnet_cidr_block=10.0.0

Error: Unsupported argument

  on main.tf line 14, in variable "subnet_cidr_block":
  14:   ephemeral = false

An argument named "ephemeral" is not expected here.
```

- task2_api_token_variable_added.png

```

variable "subnet_cidr_block" {
  type        = string
  default     = ""
  description = "CIDR block to assign to the application subnet"
  sensitive   = false
  nullable    = false
  ephemeral   = false

  validation {
    condition     = can(regex("^[0-9]{1,3}\.\.){3}[0-9]{1,3}/[0-9]+$", var.subnet_cidr_block))
    error_message = "The subnet_cidr_block must be a valid CIDR notation string, such as 10.0.0.0/24."
  }
}

variable "api_session_token" {
  type        = string
  default     = ""
  description = "Short-lived API session token used during apply operations"
  sensitive   = true
  nullable    = false
  ephemeral   = false

  validation {
    condition     = can(regex("[A-Za-z0-9-]{20,$}", var.api_session_token))
    error_message = "The API session token must be at least 20 characters and contain only letters, numbers, hyphens, or underscores."
  }
}

output "api_session_token_output" {
  value     = var.api_session_token
  sensitive = true
}

```

- task2_api_token_apply_sensitive.png

```

marlamalik11 @ /workspaces/Lab-12 (main) $ terraform apply -auto-approve -var "api_session_token=my_API_session_Token"

Changes to Outputs:
  + api_session_token_output = (sensitive value)
  ~ subnet_cidr_block_output = "10.0.40.0/24" -> "10.0.30.0/24"

You can apply this plan to save these new output values to the Terraform state, without changing any real infrastructure.

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:
api_session_token_output = <sensitive>

```

- task2_check_terraform_state_api_token.png

```

"outputs": {
  "api_session_token_output": {
    "value": "my_API_session_Token",
    "type": "string",
    "sensitive": true
  },
}

```

- task2_api_token_ephemeral_error.png

```

_cidr_block=10.0.0

Error: Invalid value for variable

on main.tf line 8:
 8: variable "subnet_cidr_block" {
   | var.subnet_cidr_block is "10.0.0"

The subnet_cidr_block must be a valid CIDR notation string, such as 10.0.0.0/24.
This was checked by the validation rule at main.tf:15,3-13.

Error: Invalid value for variable

on main.tf line 20:
20: variable "api_session_token" {
   | var.api_session_token is ""

The API session token must be at least 20 characters and contain only letters, numbers, hyphens, or underscores.
This was checked by the validation rule at main.tf:28,3-13.

```

- task2_api_token_default_apply.png

```
Terraform has compared your real infrastructure against your configuration and
no differences, so no changes are needed.

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:

api_session_token_output = <sensitive>
subnet_cidr_block_output = "10.0.30.0/24"
```

Task 3 — Project-level variables, locals, and outputs

- task3_variables_added.png

```
provider "aws" {
  shared_config_files = ["~/.aws/config"]
  shared_credentials_files = ["~/.aws/credentials"]
}
variable "environment" {}
variable "project_name" {}
variable "primary_subnet_id" {}
variable "subnet_count" {}
variable "monitoring" {}
```

- task3_locals_tf_created.png

```
locals {
  resource_name = "${var.project_name}-${var.environment}"
  primary_public_subnet = var.primary_subnet_id
  subnet_count = var.subnet_count
  is_production = var.environment == "prod"
  monitoring_enabled = var.monitoring || local.is_production
}
```

- task3_outputs_apply.png

```
Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:

is_production = false
monitoring_enabled = true
primary_public_subnet = "subnet-0fb24971d181efddb"
resource_name = "lab_work-dev"
subnet_count = 3
```

Task 4 — Maps and Objects

- task4_tags_variable_added.png

```
output "is_production" {
  value = local.is_production
}
output "monitoring_enabled" {
  value = local.monitoring_enabled
}
variable "tags" {
  type = map(string)
}
output "tags" {
  value = var.tags
}
```

- task4_tags_output.png

```
Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:

is_production = false
monitoring_enabled = true
primary_public_subnet = "subnet-0fb24971d181efddb"
resource_name = "lab_work-dev"
subnet_count = 3
tags = tomap({
  "Environment" = "dev"
  "Owner" = "platform-team"
  "Project" = "sample-app"
})
```

- task4_server_config_output.png

```
You can apply this plan to save these new output values to the Terraform state, without
infrastructure.

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:

is_production = false
monitoring_enabled = true
primary_public_subnet = "subnet-0fb24971d181efddb"
resource_name = "lab_work-dev"
server_config = {
  "backup_enabled" = false
  "instance_type" = "t3.micro"
  "monitoring" = true
  "name" = "web-server"
  "storage_gb" = 20
}
subnet_count = 3
tags = tomap({
  "Environment" = "dev"
  "Project" = "lab_work"
})
```

Task 5 — Collections: list, tuple, set & mutation via locals

- task5_collections_defined.png

```
variable "server_names" {
  type = list(string)
  default = ["web-2", "web-1", "web-2"]
}

variable "server_metadata" {
  type = tuple([string, number, bool])
  default = ["web-1", 4, true]
}

variable "availability_zones" {
  type = set(string)
  default = ["me-central-1b", "me-central-1a", "me-central-1b"]
}

output "compare_collections" {
  value = {
    list_example = var.server_names
    tuple_example = var.server_metadata
    set_example = var.availability_zones
  }
}
```

main.tf" 59L, 1435B

- task5_compare_collections.png

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:

```
compare_collections = {
  "list_example" = tolist([
    "web-2",
    "web-1",
    "web-2",
  ])
  "set_example" = toset([
    "me-central-1a",
    "me-central-1b",
  ])
  "tuple_example" = [
    "web-1",
    4,
    true,
  ]
}
is_production = false
monitoring_enabled = true
primary_public_subnet = "subnet-0fb24971d181efddb"
resource_name = "lab_work-dev"
server_config = {
  "backup_enabled" = false
  "instance_type" = "t3.micro"
  "monitoring" = true
  "name" = "web-server"
  "storage_gb" = 20
}
subnet_count = 3
tags = tomap({
  "Environment" = "dev"
  "Project" = "lab_work"
})
```

- task5_locals_mutations.png

```
locals {
  resource_name = "${var.project_name}-${var.environment}"
  primary_public_subnet = var.primary_subnet_id
  subnet_count = var.subnet_count
  is_production = var.environment == "prod"
  monitoring_enabled = var.monitoring || local.is_production
  mutated_list = setunion(var.server_names, ["web-3"])
  mutated_tuple = setunion(var.server_metadata, ["web-2"])
  mutated_set = setunion(var.availability_zones, ["me-central-1c"])
```

- task5_mutation_comparison.png

```
mutation_comparison = {
  "mutated_tuple" = toset([
    "4",
    "true",
    "web-1",
    "web-2",
  ])
  "original_tuple" = [
    "web-1",
    4,
    true,
  ]
}
```

Task 6 — Null, any type & dynamic values

- task6_optional_tag_variable.png

```

variable "optional_tag" {
  type      = string
  description = "A tag that may or may not be provided"
  default    = null
}
:wq_

```

- task6_locals_merge.png

```

mutated_set = setunion(var.availability_zones, ["me-central-1c"])
server_tags = merge(
  { Name = "web-server" },
  var.optional_tag != null ? { Custom = var.optional_tag } : {}
)

```

- task6_optional_tag_no_value.png

```

}
optional_tag = {
  "Name" = "web-server"
}
primary_public_subnet = "subnet-96ba4071d19c

```

- task6_optional_tag_with_value.png

```

}
optional_tag = {
  "Custom" = "dev"
  "Name" = "web-server"
}

```

- task6_dynamic_value_string.png

```

"Project" = "lab_work"
})
value_received = "hello"

```

- task6_dynamic_value_number.png

```

"Project" = "lab_work"
})
value_received = 42

```

- task6_dynamic_value_list.png

```

})
value_received = [
  "a",
  "b",
  "c",
]

```

- task6_dynamic_value_map.png

```

})
value_received = {
  "cpu" = 4
  "name" = "server"
}

```

- task6_dynamic_value_null.png(previous outputs only)

```

subnet_count = 3
tags = tomap({
  "Environment" = "dev"
  "Project" = "lab_work"
})
@mariamalik11 /workspaces/

```


Task 7 — Git ignore

- task7_gitignore_created.png

```
.terraform/*
*.tfstate
*.tfstate.*
*.tfvars
*.pem
```

Task 8 — Clean-up then build real infra (VPC, Subnet, IGW, routing, default route table)

- task8_clean_files.png

```
@mariamalik11 [ ] /workspaces/Lab-12 (main) $ cat main.tf
provider "aws" {
  shared_config_files      = ["~/.aws/config"]
  shared_credentials_files = ["~/.aws/credentials"]
}

@mariamalik11 [ ] /workspaces/Lab-12 (main) $ cat locals.tf

@mariamalik11 [ ] /workspaces/Lab-12 (main) $ cat terraform.tfvars
```

- task8_variables_recreated.png

```
provider "aws" {
  shared_config_files      = ["~/.aws/config"]
  shared_credentials_files = ["~/.aws/credentials"]
}

variable "vpc_cidr_block" {}
variable "subnet_cidr_block" {}
variable "availability_zone" {}
variable "env_prefix" {}
```

- task8_vpc_resources_added.png

```
resource "aws_vpc" "myapp_vpc" {
  cidr_block = var.vpc_cidr_block
  tags = {
    Name = "${var.env_prefix}-vpc"
  }
}
```

- task8_subnet_resources_added.png

```
resource "aws_subnet" "myapp_subnet_1" {
  vpc_id            = aws_vpc.myapp_vpc.id
  cidr_block        = var.subnet_cidr_block
  availability_zone = var.availability_zone
  tags = {
    Name = "${var.env_prefix}-subnet-1"
  }
}
```

- task8_terraform_tfvars_vpc_values.png

```
@mariamalik11 @ /workspaces/Lab-12 (main) $ cat terraform.tfvars
cidr_block      = "10.0.0.0/16"
subnet_cidr_block = "10.0.10.0/24"
availability_zone = "me-central-1a"
env_prefix      = "dev"
```

- task8_vpc_subnet_apply.png

```
    } -> null
- subnet_count      = 3 -> null
- tags              = {
  - Environment = "dev"
  - Project     = "lab_work"
} -> null
aws_vpc.myapp_vpc: Creating...
aws_vpc.myapp_vpc: Creation complete after 2s [id=vpc-08252caaa1aa56486]
aws_subnet.myapp_subnet_1: Creating...
aws_subnet.myapp_subnet_1: Creation complete after 1s [id=subnet-085e497731236d6]

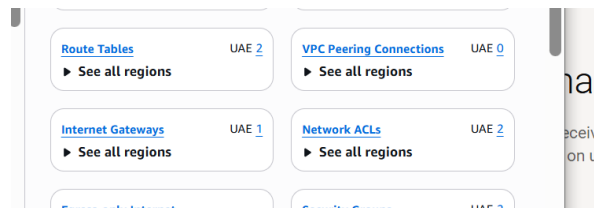
Warning: Value for undeclared variable

The root module does not declare a variable named "cidr_block" but a value
was found in file "terraform.tfvars". If you meant to use this value, add a
"variable" block to the configuration.

To silence these warnings, use TF_VAR_... environment variables to provide
certain "global" settings to all configurations in your organization. To
reduce the verbosity of these warnings, use the -compact-warnings option.

Apply complete! Resources: 2 added, 0 changed, 0 destroyed.
```

- task8_igw_route_table_before_apply.png



- task8_igw_route_table_after_apply.png

```
Plan: 2 to add, 0 to change, 0 to destroy.
aws_internet_gateway.myapp_igw: Creating...
aws_internet_gateway.myapp_igw: Creation complete after 0s [id=igw-0726e8ff4b6]
aws_route_table.myapp_route_table: Creating...
aws_route_table.myapp_route_table: Creation complete after 1s [id=rtb-02a8137f4aa]

Warning: Value for undeclared variable

The root module does not declare a variable named "cidr_block" but a
value was found in file "terraform.tfvars". If you meant to use this
value, add a "variable" block to the configuration.

To silence these warnings, use TF_VAR_... environment variables to
provide certain "global" settings to all configurations in your
organization. To reduce the verbosity of these warnings, use the
-compact-warnings option.

Apply complete! Resources: 2 added, 0 changed, 0 destroyed.
```

- task8_association_apply.png

```
provide certain "global" settings to all configurations in your
organization. To reduce the verbosity of these warnings, use the
-compact-warnings option.

Apply complete! Resources: 1 added, 0 changed, 0 destroyed.
```

- task8_default_route_table.png

```

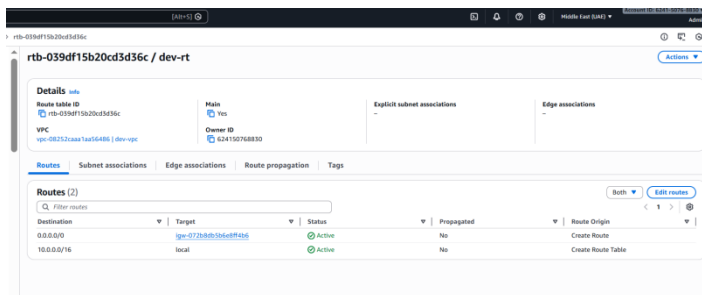
resource "aws_default_route_table" "main_rt" {
  default_route_table_id = aws_vpc.myapp_vpc.default_route_table_id

  route {
    cidr_block = "0.0.0.0/0"
    gateway_id = aws_internet_gateway.myapp_igw.id
  }

  tags = {
    Name = "${var.env_prefix}-rt"
  }
}

```

- task8_default_route_table_apply.png



Task 9 — Security Group, Key Pair, EC2 Instance, user_data & nginx

- task9_my_ip_variable_added.png

```

}
variable "my_ip" {}

```

- task9_security_group_apply.png

```

}
variable "my_ip" {}
resource "aws_default_security_group" "myapp_sg" {
  vpc_id = aws_vpc.myapp_vpc.id

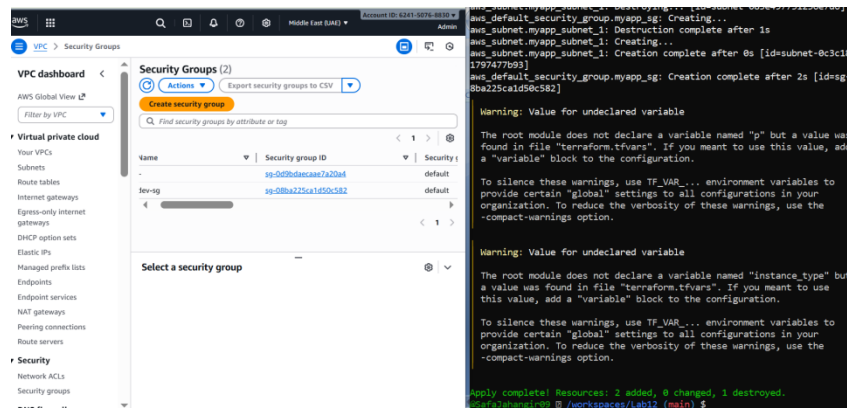
  ingress {
    from_port = 22
    to_port   = 22
    protocol  = "tcp"
    cidr_blocks = [var.my_ip]
  }

  ingress {
    from_port = 80
    to_port   = 80
    protocol  = "tcp"
    cidr_blocks = ["0.0.0.0/0"]
  }

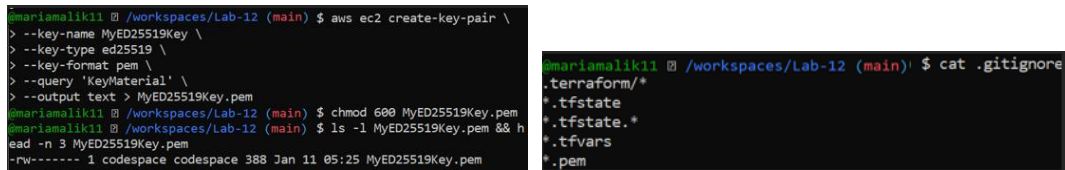
  egress {
    from_port = 0
    to_port   = 0
    protocol  = "-1"
    cidr_blocks = ["0.0.0.0/0"]
    prefix_list_ids = []
  }

  tags = {
    Name = "${var.env_prefix}-sg"
  }
}

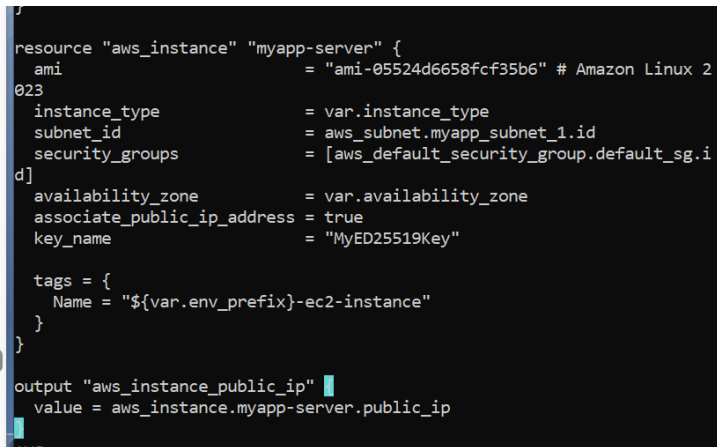
```



- task9_keypair_created_and_saved.png



- task9_instance_type_set.png



- task9_ec2_apply_and_public_ip.png

```
Plan: 2 to add, 0 to change, 0 to destroy.
```

Changes to Outputs:

```
+ aws_instance_public_ip = (known after apply)
aws_default_security_group.default_sg: Creating...
aws_default_security_group.default_sg: Creation complete after 3s [id=i-08ba225ca1d50c582]
aws_instance.myapp-server: Creating...
aws_instance.myapp-server: Still creating... [10s elapsed]
aws_instance.myapp-server: Creation complete after 13s [id=i-092574a5e362]
```

Apply complete! Resources: 2 added, 0 changed, 0 destroyed.

Outputs:

```
aws_instance_public_ip = "3.29.123.61"
```

```
aws_key_pair.ssh_key: Creating...
aws_key_pair.ssh_key: Creation complete after 0s [id=serverkey]
aws_instance.myapp-server: Creating...
aws_instance.myapp-server: Still creating... [10s elapsed]
aws_instance.myapp-server: Creation complete after 13s [id=i-0aa92f3b12708c624]

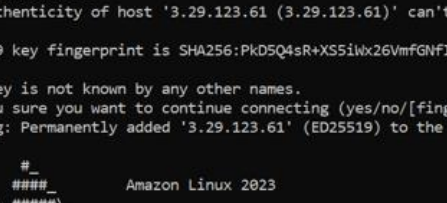
Apply complete! Resources: 2 added, 1 changed, 1 destroyed.

Outputs:

aws_instance_public_ip = "3.29.123.215"
```

- task9_ssh_into_ec2.png

```
marimallik1@ /workspaces/Lab-12 (main) $ ssh -i MyED25519Key.pem ec2-user@3.29.123.61
The authenticity of host '3.29.123.61 (3.29.123.61)' can't be established.
ED25519 key fingerprint is SHA256:Pkd5Q4sR+XS5iwX26VmfGNfIDiJeA7QYu8JLojD8XJI.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '3.29.123.61' (ED25519) to the list of known hosts.
```



```
[ec2-user@ip-10-0-118-31 ~]$ exit
logout
Connection to 3.29.123.61 closed.
```

- task9_ssh_keypair_and_ssh.png

```

jamarilama1k11 @ /workspaces/Lab-12 (main) $ ssh-keygen -t ed25519 -f ~/.ssh/id_ed25519 -N ""
Generating public/private ed25519 key pair.
/home/codespace/.ssh/id_ed25519 already exists.
Overwrite (y/n)? y
Your identification has been saved in /home/codespace/.ssh/id_ed25519
Your public key has been saved in /home/codespace/.ssh/id_ed25519.pub
The key fingerprint is:
SHA256:H4M4AV/S8lIBIXRShnO43PsJRPMSN1A3HvDBiLMvOQ8 codespace@codespaces-6c3a52
The key's randomart image is:
+--[ED25519 256]--+
|
|..+.O=O+O+=
|o *o+B ++.
|o..= O .O
|o+.B .
|o S=O=
|...Eo.
|..B .
|+
+-----[SHA256]-----+

```