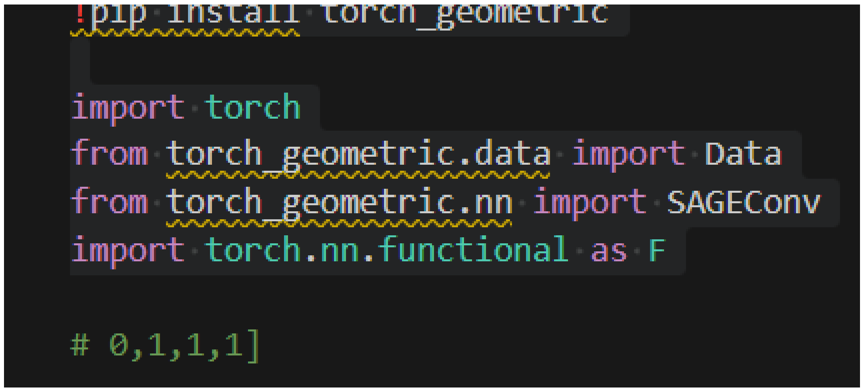
Report

1.

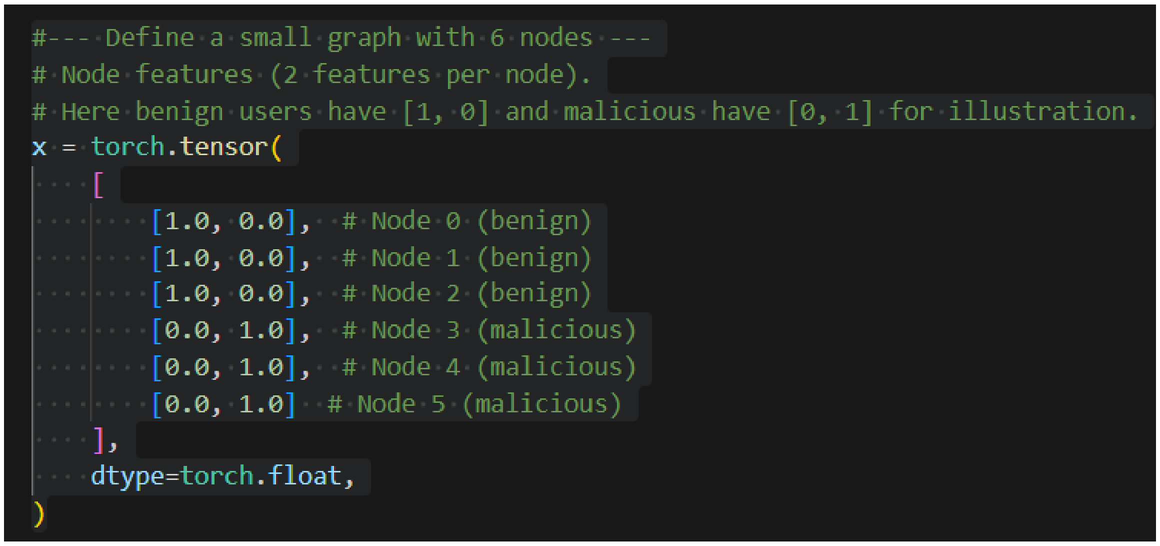


```
!pip install torch_geometric

import torch
from torch_geometric.data import Data
from torch_geometric.nn import SAGEConv
import torch.nn.functional as F

# 0,1,1,1]
```

Explanation:

a) pip install torch_geometric: installs the **torch_geometric** library, which is used for building Graph Neural Networks
b) torch: is the main PyTorch library for tensors and mode
c) Data: represents a full graph (nodes + edges + labels)
d) SAGEConv: is the GraphSAGE convolution layer.
e) F: contains useful neural network functions like ReLU and log_softmax.

2.



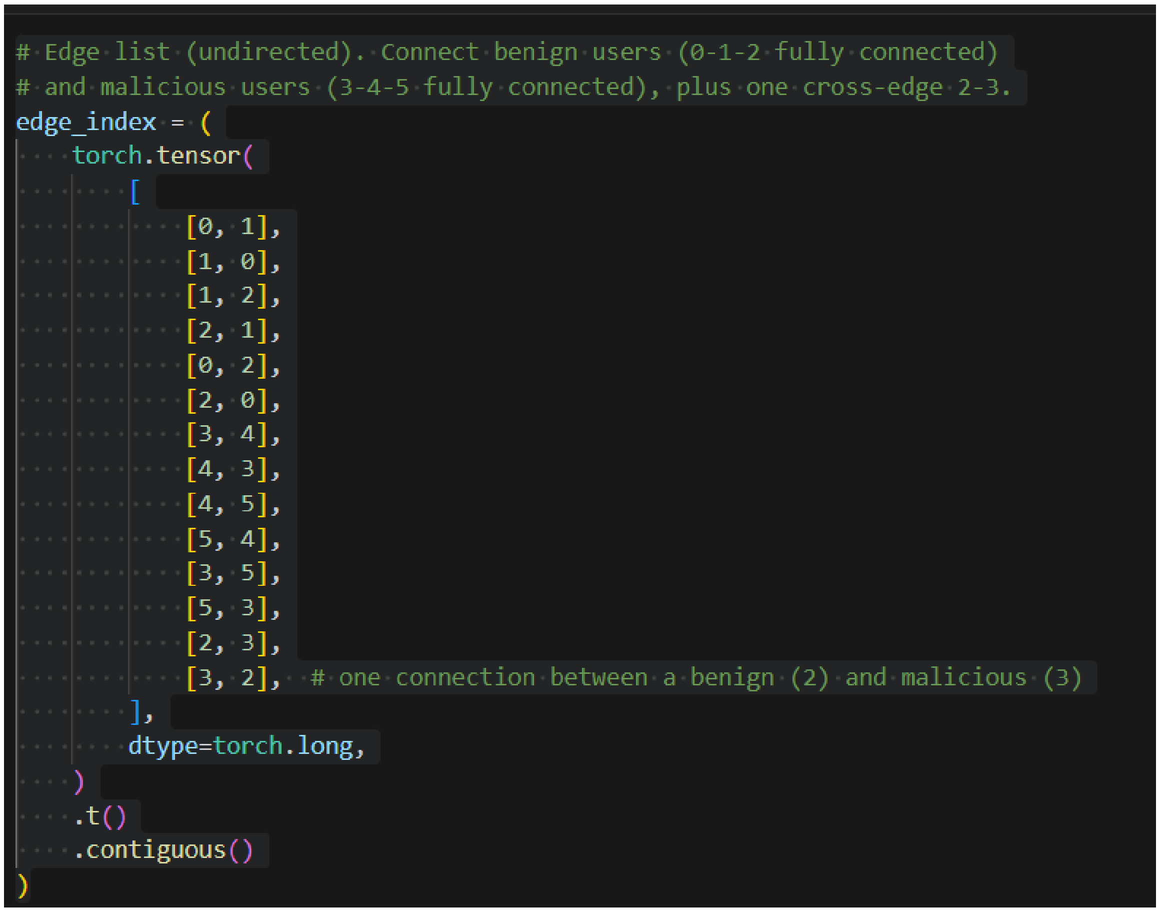
```
#--- Define a small graph with 6 nodes ---
# Node features (2 features per node).
# Here benign users have [1, 0] and malicious have [0, 1] for illustration.
x = torch.tensor(
    [
        [1.0, 0.0],  # Node 0 (benign)
        [1.0, 0.0],  # Node 1 (benign)
        [1.0, 0.0],  # Node 2 (benign)
        [0.0, 1.0],  # Node 3 (malicious)
        [0.0, 1.0],  # Node 4 (malicious)
        [0.0, 1.0]  # Node 5 (malicious)
    ],
    dtype=torch.float,
)
```

Explanation:

Each node has 2 features:

- [1, 0] means the user is **benign**
- [0, 1] means the user is **malicious**

3.



```python
# Edge list (undirected). Connect benign users (0-1-2 fully connected)
# and malicious users (3-4-5 fully connected), plus one cross-edge 2-3.
edge_index = (
    torch.tensor(
        [
            [0, 1],
            [1, 0],
            [1, 2],
            [2, 1],
            [0, 2],
            [2, 0],
            [3, 4],
            [4, 3],
            [4, 5],
            [5, 4],
            [3, 5],
            [5, 3],
            [2, 3],
            [3, 2],  # one connection between a benign (2) and malicious (3)
        ],
        dtype=torch.long,
    )
    .t()
    .contiguous()
)
```

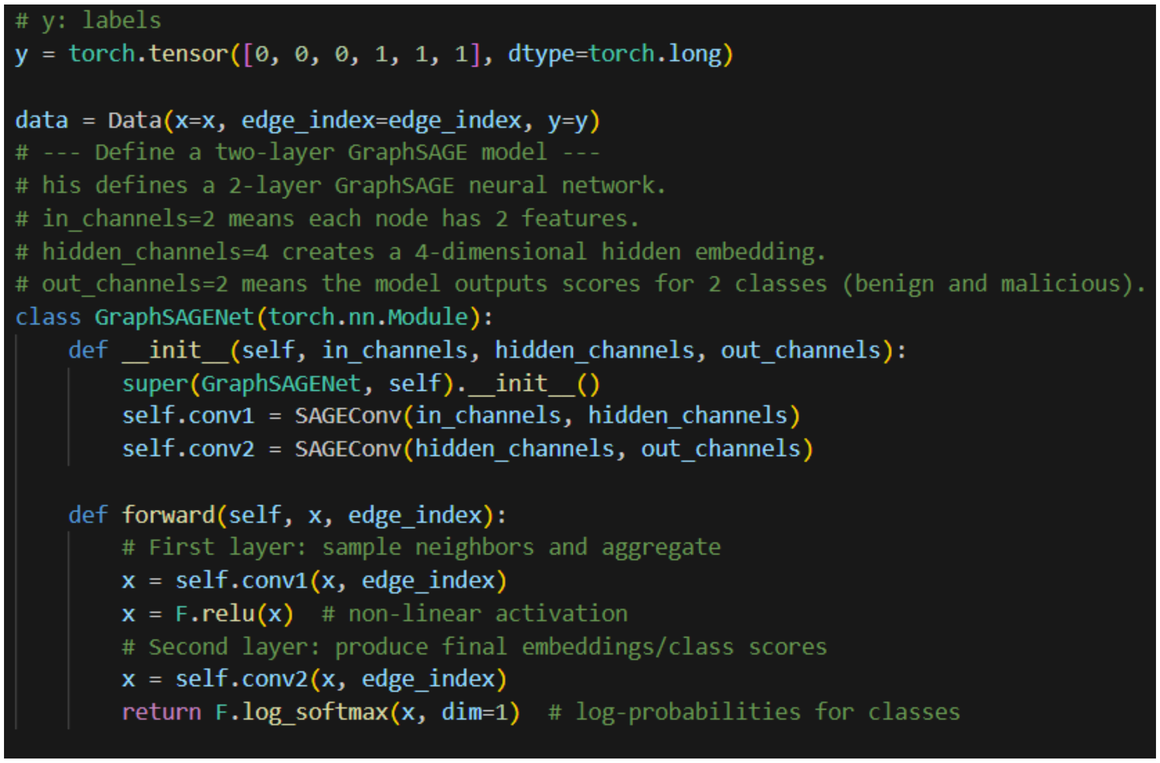
Explanation:

a) Nodes 0,1,2 form a fully connected benign group

b) Nodes 3,4,5 form a fully connected malicious group

c) There is one cross-edge between node 2 (benign) and node 3 (malicious)

4.



```
# y: labels
y = torch.tensor([0, 0, 0, 1, 1, 1], dtype=torch.long)

data = Data(x=x, edge_index=edge_index, y=y)
# --- Define a two-layer GraphSAGE model ---
# his defines a 2-layer GraphSAGE neural network.
# in_channels=2 means each node has 2 features.
# hidden_channels=4 creates a 4-dimensional hidden embedding.
# out_channels=2 means the model outputs scores for 2 classes (benign and malicious).
class GraphSAGENet(torch.nn.Module):
    def __init__(self, in_channels, hidden_channels, out_channels):
        super(GraphSAGENet, self).__init__()
        self.conv1 = SAGEConv(in_channels, hidden_channels)
        self.conv2 = SAGEConv(hidden_channels, out_channels)

    def forward(self, x, edge_index):
        # First layer: sample neighbors and aggregate
        x = self.conv1(x, edge_index)
        x = F.relu(x)  # non-linear activation
        # Second layer: produce final embeddings/class scores
        x = self.conv2(x, edge_index)
        return F.log_softmax(x, dim=1)  # log-probabilities for classes
```

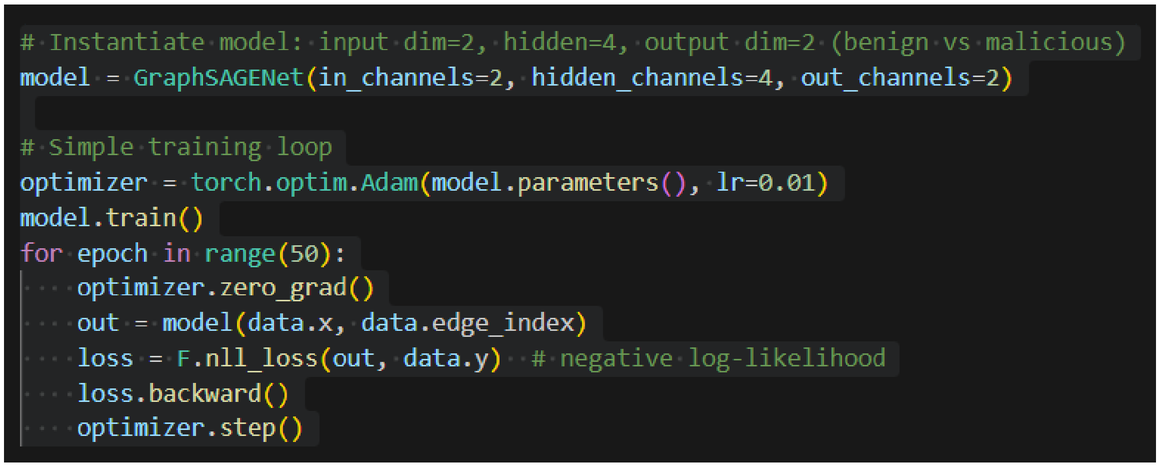
a) 0 = benign, 1 = malicious

b) Combine(node features x, graph edges edge_index, labels y) into one Data object

c) First layer: converts 2 input features → 4 hidden features
Second layer: converts 4 hidden features → 2 output classes

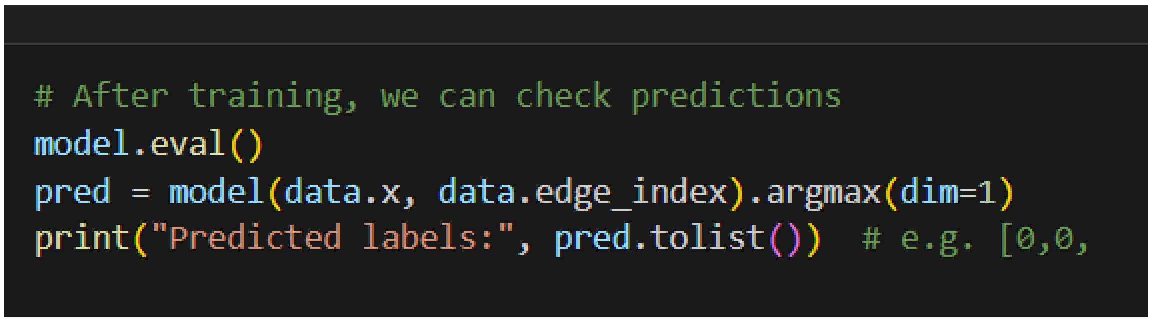
d) Convert outputs into log-probabilities for the 2 classes

5.


```
# Instantiate model: input dim=2, hidden=4, output dim=2 (benign vs malicious)
model = GraphSAGENet(in_channels=2, hidden_channels=4, out_channels=2)

# Simple training loop
optimizer = torch.optim.Adam(model.parameters(), lr=0.01)
model.train()
for epoch in range(50):
    optimizer.zero_grad()
    out = model(data.x, data.edge_index)
    loss = F.nll_loss(out, data.y)  # negative log-likelihood
    loss.backward()
    optimizer.step()
```

a) create a GraphSAGE model
b) use the Adam optimizer with a learning rate of 0.01
c) loop trains the model for 50 epochs by calculating the loss then backpropagation and updating

6.


```
# After training, we can check predictions
model.eval()
pred = model(data.x, data.edge_index).argmax(dim=1)
print("Predicted labels:", pred.tolist())  # e.g. [0,0,
```

evaluation mode and make predictions for all 6 nodes