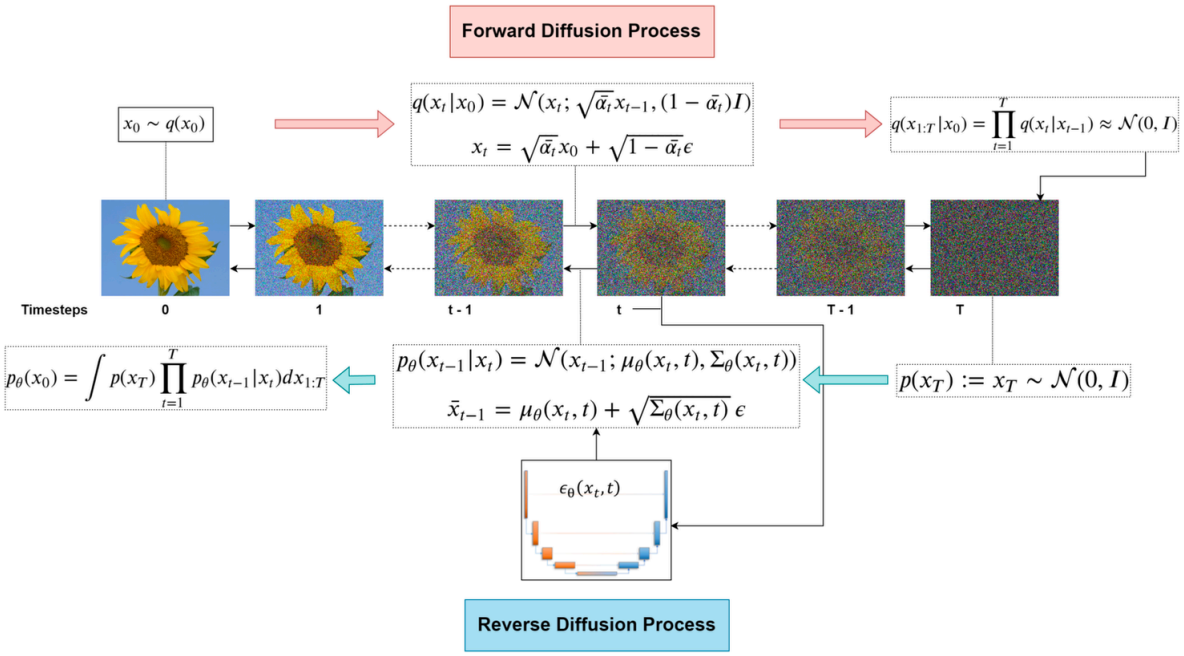


In [1]:
```
import os
import numpy as np
import math
import tensorflow as tf
from tensorflow.keras import layers, Model
from tensorflow import keras
import matplotlib.pyplot as plt
```

In [2]:
```
IMG_SHAPE = (28,28,1)
BATCH_SIZE = 128
EPOCHS = 200
T = 200
beta_start = 1e-4
beta_end = 0.02
LR = 2e-4
```

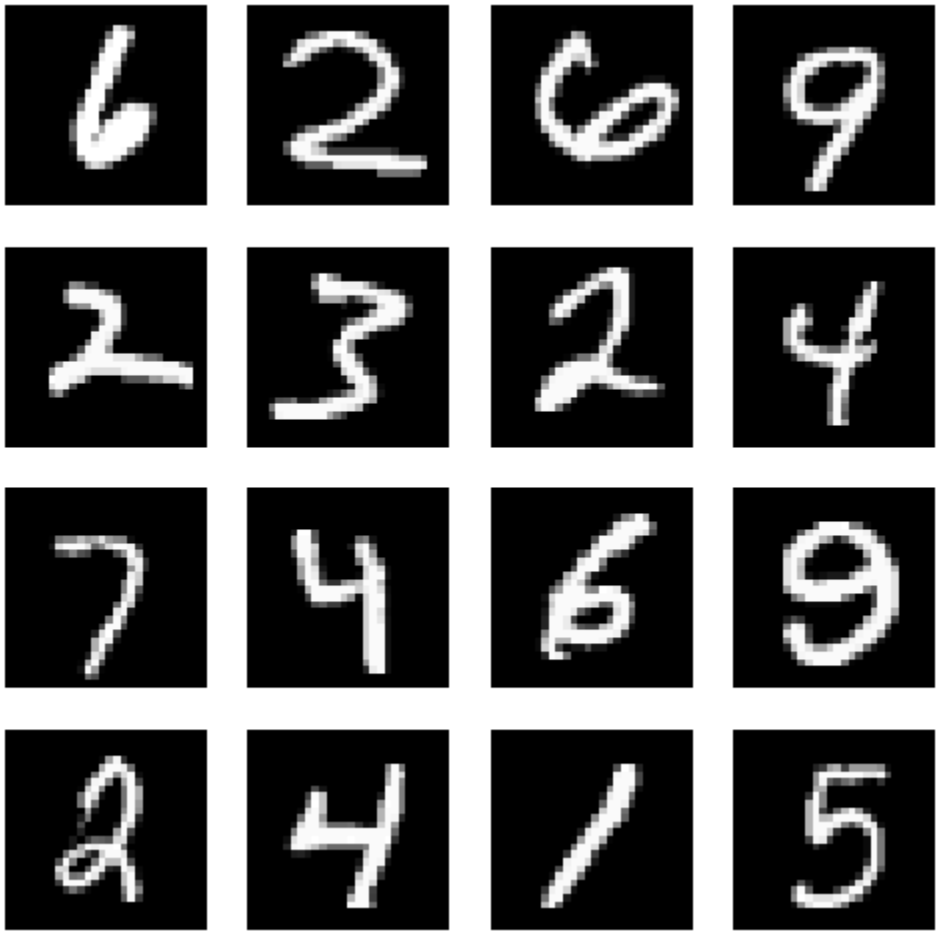
In [3]:
```
# Load MNIST scaled to [-1,1]
(x_train, _), (x_test, _) = keras.datasets.mnist.load_data()
x = np.concatenate([x_train, x_test], axis=0).astype(np.float32)
x = x[..., None] / 127.5 - 1.0
dataset = tf.data.Dataset.from_tensor_slices(x).shuffle(10000).batch(BATCH_SIZ
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datase
ts/mnist.npz
11490434/11490434 ━━━━━━━━━━━━━━━━━━━━ 0s 0us/step
```

In [4]:
```
# Function to plot images
def plot_images(images, num_rows=4, num_cols=4):
    images = (images + 1.0) / 2.0  # scale back to [0,1] for plotting
    fig, axes = plt.subplots(num_rows, num_cols, figsize=(6,6))
    idx = 0
    for i in range(num_rows):
        for j in range(num_cols):
```

```
            axes[i, j].imshow(images[idx].squeeze(), cmap="gray")
            axes[i, j].axis("off")
            idx += 1
    plt.show()

# Get one batch from dataset and plot
sample_batch = next(iter(dataset))
plot_images(sample_batch.numpy()[:16], num_rows=4, num_cols=4)
```



$$\beta_t = \text{linear interpolation from } \beta_{\text{start}} \text{ to } \beta_{\text{end}}, \quad t = 1, 2, \ldots, T$$

$$\alpha_t = 1 - \beta_t$$

$$\bar{\alpha}_t = \prod_{i=1}^{t} \alpha_i$$

$$\sqrt{\bar{\alpha}_t}, \quad \sqrt{1 - \bar{\alpha}_t}$$

In [5]:
```
# Beta schedule (linear)
```

```
betas = np.linspace(beta_start, beta_end, T, dtype=np.float32)
alphas = 1.0 - betas
alpha_cumprod = np.cumprod(alphas, axis=0).astype(np.float32)  # \bar{alpha}_t
sqrt_alpha_cumprod = np.sqrt(alpha_cumprod)
sqrt_one_minus_alpha_cumprod = np.sqrt(1.0 - alpha_cumprod)
```

In [6]:
```
# Fixed sinusoidal embedding
def sinusoidal_time_embedding(timesteps, dim=128):
    # timesteps: (batch,) int32
    timesteps = tf.cast(timesteps, tf.float32)  # ensure float
    half = dim // 2
    freqs = tf.exp(-math.log(10000.0) * tf.range(0, half, dtype=tf.float32) /
    args = tf.expand_dims(timesteps, -1) * tf.expand_dims(freqs, 0)  # (batch,
    emb = tf.concat([tf.sin(args), tf.cos(args)], axis=-1)  # (batch, dim)
    if dim % 2 == 1:
        emb = tf.pad(emb, [[0,0],[0,1]])
    return emb
```

In [7]:
```
class TimeEmbedding(layers.Layer):
    def __init__(self, dim):
        super().__init__()
        self.d1 = layers.Dense(dim, activation="swish")
        self.d2 = layers.Dense(dim, activation="swish")
        self.dim = dim
    def call(self, t):
        emb = sinusoidal_time_embedding(t, self.dim)
        return self.d2(self.d1(emb))
```

In [8]:
```
# Residual Block with time embedding
def ResidualBlock(x, t_emb, filters, name):
    # Project time embedding to channel dimension
    t_proj = layers.Dense(filters, activation='swish')(t_emb)
    t_proj = layers.Reshape((1, 1, filters))(t_proj)

    h = layers.Conv2D(filters, 3, padding='same')(x)
    h = layers.GroupNormalization()(h)
    h = layers.Activation('swish')(h)

    # Inject time embedding
    h = layers.Add()([h, t_proj])

    h = layers.Conv2D(filters, 3, padding='same')(h)
    h = layers.GroupNormalization()(h)

    # Residual connection
    if x.shape[-1] != filters:
        x = layers.Conv2D(filters, 1, padding='same')(x)

    out = layers.Add()([x, h])
    out = layers.Activation('swish', name=f"{name}_out")(out)
    return out
```

```
def build_epsilon_model(img_shape=(28,28,1), time_emb_dim=128):
    inp = layers.Input(img_shape, name='x_t')
    t_in = layers.Input(shape=(), dtype=tf.int32, name='t')

    # TimeEmbedding
    t_emb = TimeEmbedding(time_emb_dim)(t_in)

    # Encoder
    x1 = ResidualBlock(inp, t_emb, 64, name="enc1")        # 28x28
    x = layers.Conv2D(64, 3, strides=2, padding='same')(x1)

    x2 = ResidualBlock(x, t_emb, 128, name="enc2")         # 14x14
    x = layers.Conv2D(128, 3, strides=2, padding='same')(x2)

    x3 = ResidualBlock(x, t_emb, 256, name="enc3")         # 7x7

    # Bottleneck
    x = ResidualBlock(x3, t_emb, 512, name="bottleneck")

    # Decoder
    x = layers.Conv2DTranspose(256, 3, strides=2, padding='same')(x)  # 14x14
    x = layers.Concatenate()([x, x2])
    x = ResidualBlock(x, t_emb, 256, name="dec1")

    x = layers.Conv2DTranspose(128, 3, strides=2, padding='same')(x)  # 28x28
    x = layers.Concatenate()([x, x1])
    x = ResidualBlock(x, t_emb, 128, name="dec2")

    # Output
    out = layers.Conv2D(1, 3, padding='same', name='out')(x)

    return Model([inp, t_in], out, name='epsilon_model_complex')
```

In [9]:
```
# Build epsilon model
epsilon_model = build_epsilon_model(img_shape=(28, 28, 1), time_emb_dim=128)

# Define optimizer
optimizer = keras.optimizers.Adam(learning_rate=LR, beta_1=0.9, beta_2=0.999,
```

In [10]:
```
# Compile model
epsilon_model.compile(
    optimizer=optimizer,
    loss=keras.losses.MeanSquaredError(),
    metrics=[keras.metrics.MeanAbsoluteError()]
)
```

In [11]:
```
epsilon_model.summary()
```

Model: "epsilon_model_complex"

Layer (type)	Output Shape	Param #	Connected to
x_t (InputLayer)	(None, 28, 28, 1)	0	-
t (InputLayer)	(None)	0	-
conv2d (Conv2D)	(None, 28, 28, 64)	640	x_t[0][0]
time_embedding (TimeEmbedding)	(None, 128)	33,024	t[0][0]
group_normalization (GroupNormalizatio…	(None, 28, 28, 64)	128	conv2d[0][0]
dense_2 (Dense)	(None, 64)	8,256	time_embedding[0…
activation (Activation)	(None, 28, 28, 64)	0	group_normalizat…
reshape (Reshape)	(None, 1, 1, 64)	0	dense_2[0][0]
add (Add)	(None, 28, 28, 64)	0	activation[0][0], reshape[0][0]
conv2d_1 (Conv2D)	(None, 28, 28, 64)	36,928	add[0][0]
conv2d_2 (Conv2D)	(None, 28, 28, 64)	128	x_t[0][0]
group_normalizatio… (GroupNormalizatio…	(None, 28, 28, 64)	128	conv2d_1[0][0]
add_1 (Add)	(None, 28, 28, 64)	0	conv2d_2[0][0], group_normalizat…
enc1_out (Activation)	(None, 28, 28, 64)	0	add_1[0][0]
conv2d_3 (Conv2D)	(None, 14, 14, 64)	36,928	enc1_out[0][0]
conv2d_4 (Conv2D)	(None, 14, 14, 128)	73,856	conv2d_3[0][0]
group_normalizatio… (GroupNormalizatio…	(None, 14, 14, 128)	256	conv2d_4[0][0]
dense_3 (Dense)	(None, 128)	16,512	time_embedding[0…
activation_1 (Activation)	(None, 14, 14, 128)	0	group_normalizat…
reshape_1 (Reshape)	(None, 1, 1, 128)	0	dense_3[0][0]

add_2 (Add)	(None, 14, 14, 128)	0	activation_1[0][… reshape_1[0][0]
conv2d_5 (Conv2D)	(None, 14, 14, 128)	147,584	add_2[0][0]
conv2d_6 (Conv2D)	(None, 14, 14, 128)	8,320	conv2d_3[0][0]
group_normalizatio… (GroupNormalizatio…	(None, 14, 14, 128)	256	conv2d_5[0][0]
add_3 (Add)	(None, 14, 14, 128)	0	conv2d_6[0][0], group_normalizat…
enc2_out (Activation)	(None, 14, 14, 128)	0	add_3[0][0]
conv2d_7 (Conv2D)	(None, 7, 7, 128)	147,584	enc2_out[0][0]
conv2d_8 (Conv2D)	(None, 7, 7, 256)	295,168	conv2d_7[0][0]
group_normalizatio… (GroupNormalizatio…	(None, 7, 7, 256)	512	conv2d_8[0][0]
dense_4 (Dense)	(None, 256)	33,024	time_embedding[0…
activation_2 (Activation)	(None, 7, 7, 256)	0	group_normalizat…
reshape_2 (Reshape)	(None, 1, 1, 256)	0	dense_4[0][0]
add_4 (Add)	(None, 7, 7, 256)	0	activation_2[0][… reshape_2[0][0]
conv2d_9 (Conv2D)	(None, 7, 7, 256)	590,080	add_4[0][0]
conv2d_10 (Conv2D)	(None, 7, 7, 256)	33,024	conv2d_7[0][0]
group_normalizatio… (GroupNormalizatio…	(None, 7, 7, 256)	512	conv2d_9[0][0]
add_5 (Add)	(None, 7, 7, 256)	0	conv2d_10[0][0], group_normalizat…
enc3_out (Activation)	(None, 7, 7, 256)	0	add_5[0][0]
conv2d_11 (Conv2D)	(None, 7, 7, 512)	1,180,160	enc3_out[0][0]
group_normalizatio… (GroupNormalizatio…	(None, 7, 7, 512)	1,024	conv2d_11[0][0]
dense_5 (Dense)	(None, 512)	66,048	time_embedding[0…

activation_3 (Activation)	(None, 7, 7, 512)	0	group_normalizat…
reshape_3 (Reshape)	(None, 1, 1, 512)	0	dense_5[0][0]
add_6 (Add)	(None, 7, 7, 512)	0	activation_3[0][… reshape_3[0][0]
conv2d_12 (Conv2D)	(None, 7, 7, 512)	2,359,808	add_6[0][0]
conv2d_13 (Conv2D)	(None, 7, 7, 512)	131,584	enc3_out[0][0]
group_normalizatio… (GroupNormalizatio…	(None, 7, 7, 512)	1,024	conv2d_12[0][0]
add_7 (Add)	(None, 7, 7, 512)	0	conv2d_13[0][0], group_normalizat…
bottleneck_out (Activation)	(None, 7, 7, 512)	0	add_7[0][0]
conv2d_transpose (Conv2DTranspose)	(None, 14, 14, 256)	1,179,904	bottleneck_out[0…
concatenate (Concatenate)	(None, 14, 14, 384)	0	conv2d_transpose… enc2_out[0][0]
conv2d_14 (Conv2D)	(None, 14, 14, 256)	884,992	concatenate[0][0]
group_normalizatio… (GroupNormalizatio…	(None, 14, 14, 256)	512	conv2d_14[0][0]
dense_6 (Dense)	(None, 256)	33,024	time_embedding[0…
activation_4 (Activation)	(None, 14, 14, 256)	0	group_normalizat…
reshape_4 (Reshape)	(None, 1, 1, 256)	0	dense_6[0][0]
add_8 (Add)	(None, 14, 14, 256)	0	activation_4[0][… reshape_4[0][0]
conv2d_15 (Conv2D)	(None, 14, 14, 256)	590,080	add_8[0][0]
conv2d_16 (Conv2D)	(None, 14, 14, 256)	98,560	concatenate[0][0]
group_normalizatio… (GroupNormalizatio…	(None, 14, 14, 256)	512	conv2d_15[0][0]
add_9 (Add)	(None, 14, 14, 256)	0	conv2d_16[0][0], group_normalizat…
dec1_out	(None, 14, 14,	0	add_9[0][0]

(Activation)	256)		
conv2d_transpose_1 (Conv2DTranspose)	(None, 28, 28, 128)	295,040	dec1_out[0][0]
concatenate_1 (Concatenate)	(None, 28, 28, 192)	0	conv2d_transpose… enc1_out[0][0]
conv2d_17 (Conv2D)	(None, 28, 28, 128)	221,312	concatenate_1[0]…
group_normalizatio… (GroupNormalizatio…	(None, 28, 28, 128)	256	conv2d_17[0][0]
dense_7 (Dense)	(None, 128)	16,512	time_embedding[0…
activation_5 (Activation)	(None, 28, 28, 128)	0	group_normalizat…
reshape_5 (Reshape)	(None, 1, 1, 128)	0	dense_7[0][0]
add_10 (Add)	(None, 28, 28, 128)	0	activation_5[0][… reshape_5[0][0]
conv2d_18 (Conv2D)	(None, 28, 28, 128)	147,584	add_10[0][0]
conv2d_19 (Conv2D)	(None, 28, 28, 128)	24,704	concatenate_1[0]…
group_normalizatio… (GroupNormalizatio…	(None, 28, 28, 128)	256	conv2d_18[0][0]
add_11 (Add)	(None, 28, 28, 128)	0	conv2d_19[0][0], group_normalizat…
dec2_out (Activation)	(None, 28, 28, 128)	0	add_11[0][0]
out (Conv2D)	(None, 28, 28, 1)	1,153	dec2_out[0][0]

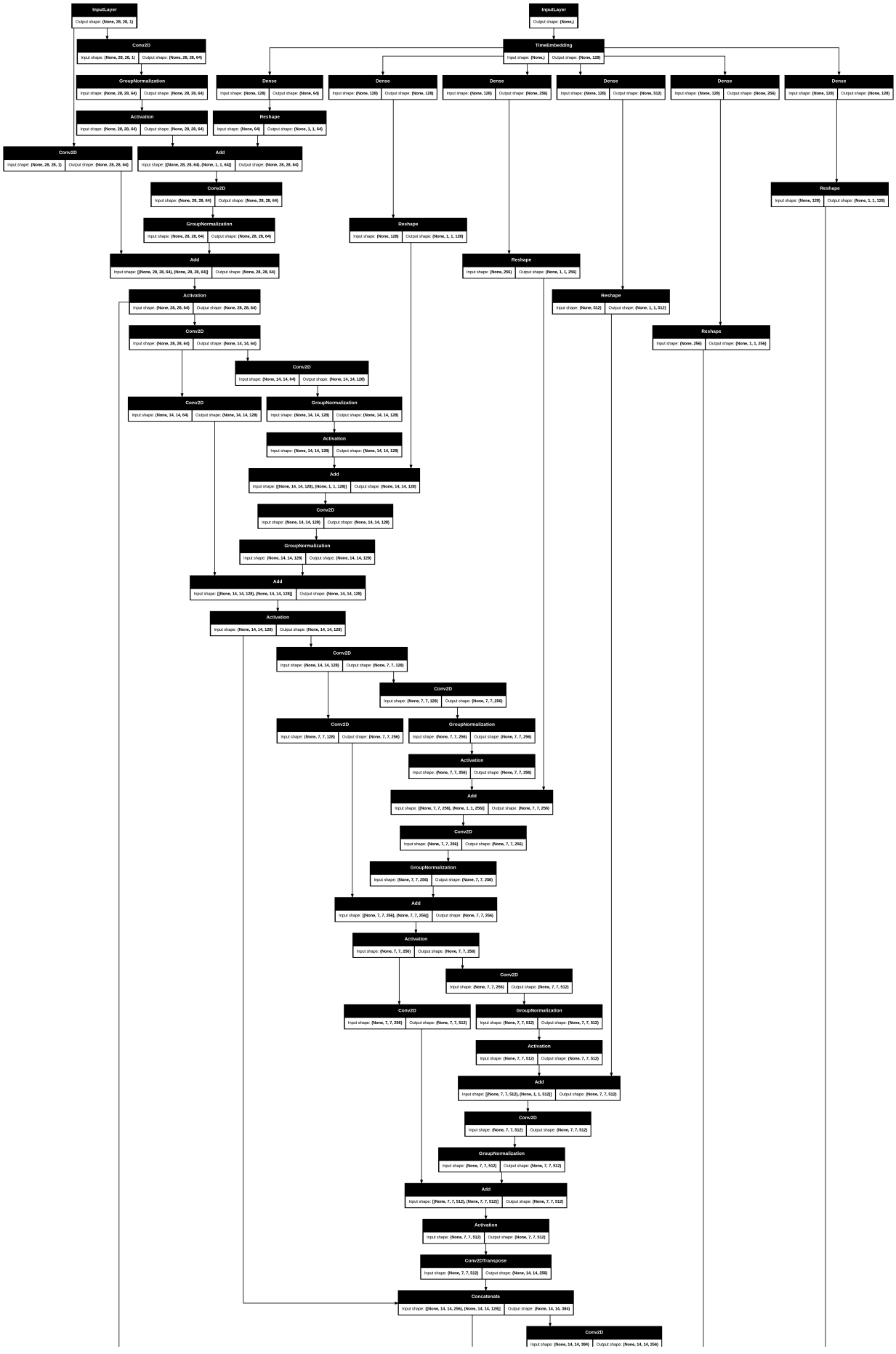
Total params: 8,696,897 (33.18 MB)

Trainable params: 8,696,897 (33.18 MB)

Non-trainable params: 0 (0.00 B)

In [12]:
```
from tensorflow.keras.utils import plot_model
plot_model(epsilon_model, show_shapes=True)
```

Out[12]:


InputLayer
Output shape: (None, 28, 28, 1)
InputLayer
Output shape: (None,)
Conv2D
Input shape: (None, 28, 28, 1) Output shape: (None, 28, 28, 64)
TimeEmbedding
Input shape: (None,) Output shape: (None, 128)
GroupNormalization
Input shape: (None, 28, 28, 64) Output shape: (None, 28, 28, 64)
Dense
Input shape: (None, 128) Output shape: (None, 64)
Dense
Input shape: (None, 128) Output shape: (None, 128)
Dense
Input shape: (None, 128) Output shape: (None, 256)
Dense
Input shape: (None, 128) Output shape: (None, 512)
Dense
Input shape: (None, 128) Output shape: (None, 256)
Dense
Input shape: (None, 128) Output shape: (None, 128)
Activation
Input shape: (None, 28, 28, 64) Output shape: (None, 28, 28, 64)
Reshape
Input shape: (None, 64) Output shape: (None, 1, 1, 64)
Conv2D
Input shape: (None, 28, 28, 1) Output shape: (None, 28, 28, 64)
Add
Input shape: [(None, 28, 28, 64), (None, 1, 1, 64)] Output shape: (None, 28, 28, 64)
Conv2D
Input shape: (None, 28, 28, 64) Output shape: (None, 28, 28, 64)
Reshape
Input shape: (None, 128) Output shape: (None, 1, 1, 128)
GroupNormalization
Input shape: (None, 28, 28, 64) Output shape: (None, 28, 28, 64)
Add
Input shape: [(None, 28, 28, 64), (None, 28, 28, 64)] Output shape: (None, 28, 28, 64)
Reshape
Input shape: (None, 256) Output shape: (None, 1, 1, 256)
Activation
Input shape: (None, 28, 28, 64) Output shape: (None, 28, 28, 64)
Reshape
Input shape: (None, 512) Output shape: (None, 1, 1, 512)
Conv2D
Input shape: (None, 28, 28, 64) Output shape: (None, 14, 14, 64)
Reshape
Input shape: (None, 256) Output shape: (None, 1, 1, 256)
Conv2D
Input shape: (None, 14, 14, 64) Output shape: (None, 14, 14, 128)
Conv2D
Input shape: (None, 14, 14, 64) Output shape: (None, 14, 14, 128)
GroupNormalization
Input shape: (None, 14, 14, 128) Output shape: (None, 14, 14, 128)
Activation
Input shape: (None, 14, 14, 128) Output shape: (None, 14, 14, 128)
Add
Input shape: [(None, 14, 14, 128), (None, 1, 1, 128)] Output shape: (None, 14, 14, 128)
Conv2D
Input shape: (None, 14, 14, 128) Output shape: (None, 14, 14, 128)
GroupNormalization
Input shape: (None, 14, 14, 128) Output shape: (None, 14, 14, 128)
Add
Input shape: [(None, 14, 14, 128), (None, 14, 14, 128)] Output shape: (None, 14, 14, 128)
Activation
Input shape: (None, 14, 14, 128) Output shape: (None, 14, 14, 128)
Conv2D
Input shape: (None, 14, 14, 128) Output shape: (None, 7, 7, 128)
Conv2D
Input shape: (None, 7, 7, 128) Output shape: (None, 7, 7, 256)
Conv2D
Input shape: (None, 7, 7, 128) Output shape: (None, 7, 7, 256)
GroupNormalization
Input shape: (None, 7, 7, 256) Output shape: (None, 7, 7, 256)
Activation
Input shape: (None, 7, 7, 256) Output shape: (None, 7, 7, 256)
Add
Input shape: [(None, 7, 7, 256), (None, 1, 1, 256)] Output shape: (None, 7, 7, 256)
Conv2D
Input shape: (None, 7, 7, 256) Output shape: (None, 7, 7, 256)
GroupNormalization
Input shape: (None, 7, 7, 256) Output shape: (None, 7, 7, 256)
Add
Input shape: [(None, 7, 7, 256), (None, 7, 7, 256)] Output shape: (None, 7, 7, 256)
Activation
Input shape: (None, 7, 7, 256) Output shape: (None, 7, 7, 256)
Conv2D
Input shape: (None, 7, 7, 256) Output shape: (None, 7, 7, 512)
Conv2D
Input shape: (None, 7, 7, 256) Output shape: (None, 7, 7, 512)
GroupNormalization
Input shape: (None, 7, 7, 512) Output shape: (None, 7, 7, 512)
Activation
Input shape: (None, 7, 7, 512) Output shape: (None, 7, 7, 512)
Add
Input shape: [(None, 7, 7, 512), (None, 1, 1, 512)] Output shape: (None, 7, 7, 512)
Conv2D
Input shape: (None, 7, 7, 512) Output shape: (None, 7, 7, 512)
GroupNormalization
Input shape: (None, 7, 7, 512) Output shape: (None, 7, 7, 512)
Add
Input shape: [(None, 7, 7, 512), (None, 7, 7, 512)] Output shape: (None, 7, 7, 512)
Activation
Input shape: (None, 7, 7, 512) Output shape: (None, 7, 7, 512)
Conv2DTranspose
Input shape: (None, 7, 7, 512) Output shape: (None, 14, 14, 256)
Concatenate
Input shape: [(None, 14, 14, 256), (None, 14, 14, 128)] Output shape: (None, 14, 14, 384)
Conv2D
Input shape: (None, 14, 14, 384) Output shape: (None, 14, 14, 256)

In [13]:
```
# Training step
@tf.function
def train_step(x0):
    batch_size = tf.shape(x0)[0]
    t = tf.random.uniform((batch_size,), minval=0, maxval=T, dtype=tf.int32)
    alpha_bar = tf.gather(tf.constant(sqrt_alpha_cumprod, dtype=tf.float32), t
    one_minus_alpha_bar = tf.gather(tf.constant(sqrt_one_minus_alpha_cumprod,
    alpha_bar = tf.reshape(alpha_bar, (-1,1,1,1))
    one_minus_alpha_bar = tf.reshape(one_minus_alpha_bar, (-1,1,1,1))

    eps = tf.random.normal(tf.shape(x0))
    x_t = alpha_bar * x0 + one_minus_alpha_bar * eps
    with tf.GradientTape() as tape:
        eps_pred = epsilon_model([x_t, t], training=True)
        loss = tf.reduce_mean(tf.square(eps - eps_pred))
    grads = tape.gradient(loss, epsilon_model.trainable_variables)
    optimizer.apply_gradients(zip(grads, epsilon_model.trainable_variables))
    return loss
```

In [14]:
```
# Sampling (Algorithm 2) using learned eps predictor
def sample(n_samples=16):
    x_t = tf.random.normal((n_samples,)+IMG_SHAPE)
    for t_i in reversed(range(T)):
        t_batch = tf.fill((n_samples,), tf.cast(t_i, tf.int32))
        eps_pred = epsilon_model([x_t, t_batch], training=False)
        beta_i = float(betas[t_i])
        alpha_i = float(alphas[t_i])
        alpha_bar_i = float(alpha_cumprod[t_i])
        coef = beta_i / math.sqrt(1.0 - alpha_bar_i)
        if t_i > 0:
            z = tf.random.normal(tf.shape(x_t))
        else:
            z = tf.zeros_like(x_t)
        sigma_t = math.sqrt(beta_i)  # choose sigma_t = sqrt(beta_t)
        x_t = (1.0 / math.sqrt(alpha_i)) * (x_t - coef * eps_pred) + sigma_t *
    return x_t
```

In [15]:
```
# Function to save generated images at each epoch
def save_generated_images(model, epoch, sample_fn, out_dir="/content", num_sam
    os.makedirs(out_dir, exist_ok=True)

    images = sample_fn(num_samples).numpy()
    images = (images + 1.0) * 127.5
    images = np.clip(images, 0, 255).astype(np.uint8)

    fig, axes = plt.subplots(4, 4, figsize=(6, 6))
    idx = 0
    for i in range(4):
        for j in range(4):
            axes[i, j].imshow(images[idx].squeeze(), cmap="gray")
            axes[i, j].axis("off")
            idx += 1
```

```
    plt.suptitle(f"Generated - Epoch {epoch+1}")
    file_path = ('image_at_epoch_{:04d}.png'.format(epoch))
    plt.savefig(file_path)
    plt.close()
    print(f"[INFO] Saved generated images at {file_path}")
```

In [16]:
```
# Training function
def train_model(dataset, epochs, batch_size, train_step, sample_fn):
    steps_per_epoch = int(np.ceil(len(dataset) / batch_size))

    for epoch in range(epochs):
        print(f"\nEpoch {epoch+1}/{epochs}")
        prog = tf.keras.utils.Progbar(steps_per_epoch)

        # iterate over dataset
        for step, batch in enumerate(dataset.take(steps_per_epoch)):
            loss = train_step(batch)
            prog.update(step + 1, [("loss", loss.numpy())])

        # Save generated images after each epoch
        save_generated_images(None, epoch, sample_fn)
```

In [17]:
```
train_model(dataset, EPOCHS, BATCH_SIZE, train_step, sample)
```

```
Epoch 1/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 20s 242ms/step - loss: 1.7236
[INFO] Saved generated images at image_at_epoch_0000.png

Epoch 2/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 1s 245ms/step - loss: 0.5648
[INFO] Saved generated images at image_at_epoch_0001.png

Epoch 3/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 1s 245ms/step - loss: 0.4317
[INFO] Saved generated images at image_at_epoch_0002.png

Epoch 4/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 1s 246ms/step - loss: 0.3508
[INFO] Saved generated images at image_at_epoch_0003.png

Epoch 5/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 1s 249ms/step - loss: 0.3265
[INFO] Saved generated images at image_at_epoch_0004.png

Epoch 6/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 1s 255ms/step - loss: 0.2951
[INFO] Saved generated images at image_at_epoch_0005.png

Epoch 7/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.2698
[INFO] Saved generated images at image_at_epoch_0006.png

Epoch 8/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 261ms/step - loss: 0.2599
[INFO] Saved generated images at image_at_epoch_0007.png

Epoch 9/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 266ms/step - loss: 0.2604
[INFO] Saved generated images at image_at_epoch_0008.png

Epoch 10/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.2558
[INFO] Saved generated images at image_at_epoch_0009.png

Epoch 11/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.2479
[INFO] Saved generated images at image_at_epoch_0010.png

Epoch 12/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.2234
[INFO] Saved generated images at image_at_epoch_0011.png

Epoch 13/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.2287
[INFO] Saved generated images at image_at_epoch_0012.png

Epoch 14/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.2263
```

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[INFO] Saved generated images at image_at_epoch_0013.png

Epoch 15/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.2088
[INFO] Saved generated images at image_at_epoch_0014.png

Epoch 16/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.2034
[INFO] Saved generated images at image_at_epoch_0015.png

Epoch 17/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.2111
[INFO] Saved generated images at image_at_epoch_0016.png

Epoch 18/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.1882
[INFO] Saved generated images at image_at_epoch_0017.png

Epoch 19/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.1924
[INFO] Saved generated images at image_at_epoch_0018.png

Epoch 20/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.1818
[INFO] Saved generated images at image_at_epoch_0019.png

Epoch 21/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.1829
[INFO] Saved generated images at image_at_epoch_0020.png

Epoch 22/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 266ms/step - loss: 0.1772
[INFO] Saved generated images at image_at_epoch_0021.png

Epoch 23/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.1934
[INFO] Saved generated images at image_at_epoch_0022.png

Epoch 24/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.1726
[INFO] Saved generated images at image_at_epoch_0023.png

Epoch 25/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.1739
[INFO] Saved generated images at image_at_epoch_0024.png

Epoch 26/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.1509
[INFO] Saved generated images at image_at_epoch_0025.png

Epoch 27/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 273ms/step - loss: 0.1641
[INFO] Saved generated images at image_at_epoch_0026.png
```

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Epoch 28/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.1594
[INFO] Saved generated images at image_at_epoch_0027.png

Epoch 29/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.1479
[INFO] Saved generated images at image_at_epoch_0028.png

Epoch 30/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.1503
[INFO] Saved generated images at image_at_epoch_0029.png

Epoch 31/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.1485
[INFO] Saved generated images at image_at_epoch_0030.png

Epoch 32/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.1395
[INFO] Saved generated images at image_at_epoch_0031.png

Epoch 33/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.1268
[INFO] Saved generated images at image_at_epoch_0032.png

Epoch 34/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.1279
[INFO] Saved generated images at image_at_epoch_0033.png

Epoch 35/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.1243
[INFO] Saved generated images at image_at_epoch_0034.png

Epoch 36/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.1401
[INFO] Saved generated images at image_at_epoch_0035.png

Epoch 37/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.1294
[INFO] Saved generated images at image_at_epoch_0036.png

Epoch 38/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.1329
[INFO] Saved generated images at image_at_epoch_0037.png

Epoch 39/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.1242
[INFO] Saved generated images at image_at_epoch_0038.png

Epoch 40/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 273ms/step - loss: 0.1319
[INFO] Saved generated images at image_at_epoch_0039.png

Epoch 41/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.1230
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[INFO] Saved generated images at image_at_epoch_0040.png

Epoch 42/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.1194
[INFO] Saved generated images at image_at_epoch_0041.png

Epoch 43/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.1199
[INFO] Saved generated images at image_at_epoch_0042.png

Epoch 44/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.1196
[INFO] Saved generated images at image_at_epoch_0043.png

Epoch 45/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.1160
[INFO] Saved generated images at image_at_epoch_0044.png

Epoch 46/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 273ms/step - loss: 0.1067
[INFO] Saved generated images at image_at_epoch_0045.png

Epoch 47/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 266ms/step - loss: 0.1184
[INFO] Saved generated images at image_at_epoch_0046.png

Epoch 48/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.1122
[INFO] Saved generated images at image_at_epoch_0047.png

Epoch 49/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 274ms/step - loss: 0.1118
[INFO] Saved generated images at image_at_epoch_0048.png

Epoch 50/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 1s 265ms/step - loss: 0.1120
[INFO] Saved generated images at image_at_epoch_0049.png

Epoch 51/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.1119
[INFO] Saved generated images at image_at_epoch_0050.png

Epoch 52/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 274ms/step - loss: 0.1136
[INFO] Saved generated images at image_at_epoch_0051.png

Epoch 53/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.1014
[INFO] Saved generated images at image_at_epoch_0052.png

Epoch 54/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.1074
[INFO] Saved generated images at image_at_epoch_0053.png
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Epoch 55/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.1013
[INFO] Saved generated images at image_at_epoch_0054.png

Epoch 56/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.1124
[INFO] Saved generated images at image_at_epoch_0055.png

Epoch 57/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.1012
[INFO] Saved generated images at image_at_epoch_0056.png

Epoch 58/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.1129
[INFO] Saved generated images at image_at_epoch_0057.png

Epoch 59/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 274ms/step - loss: 0.1065
[INFO] Saved generated images at image_at_epoch_0058.png

Epoch 60/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0973
[INFO] Saved generated images at image_at_epoch_0059.png

Epoch 61/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.1015
[INFO] Saved generated images at image_at_epoch_0060.png

Epoch 62/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 273ms/step - loss: 0.1007
[INFO] Saved generated images at image_at_epoch_0061.png

Epoch 63/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.1036
[INFO] Saved generated images at image_at_epoch_0062.png

Epoch 64/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.1082
[INFO] Saved generated images at image_at_epoch_0063.png

Epoch 65/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.1047
[INFO] Saved generated images at image_at_epoch_0064.png

Epoch 66/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0996
[INFO] Saved generated images at image_at_epoch_0065.png

Epoch 67/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.1071
[INFO] Saved generated images at image_at_epoch_0066.png

Epoch 68/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0986
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[INFO] Saved generated images at image_at_epoch_0067.png

Epoch 69/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.1013
[INFO] Saved generated images at image_at_epoch_0068.png

Epoch 70/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.1003
[INFO] Saved generated images at image_at_epoch_0069.png

Epoch 71/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 266ms/step - loss: 0.1003
[INFO] Saved generated images at image_at_epoch_0070.png

Epoch 72/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0981
[INFO] Saved generated images at image_at_epoch_0071.png

Epoch 73/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 273ms/step - loss: 0.1015
[INFO] Saved generated images at image_at_epoch_0072.png

Epoch 74/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 266ms/step - loss: 0.0924
[INFO] Saved generated images at image_at_epoch_0073.png

Epoch 75/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0923
[INFO] Saved generated images at image_at_epoch_0074.png

Epoch 76/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 277ms/step - loss: 0.0939
[INFO] Saved generated images at image_at_epoch_0075.png

Epoch 77/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0989
[INFO] Saved generated images at image_at_epoch_0076.png

Epoch 78/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 266ms/step - loss: 0.0956
[INFO] Saved generated images at image_at_epoch_0077.png

Epoch 79/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 266ms/step - loss: 0.0936
[INFO] Saved generated images at image_at_epoch_0078.png

Epoch 80/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 264ms/step - loss: 0.0953
[INFO] Saved generated images at image_at_epoch_0079.png

Epoch 81/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0942
[INFO] Saved generated images at image_at_epoch_0080.png
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Epoch 82/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 275ms/step - loss: 0.0920
[INFO] Saved generated images at image_at_epoch_0081.png

Epoch 83/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 265ms/step - loss: 0.0931
[INFO] Saved generated images at image_at_epoch_0082.png

Epoch 84/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 1s 251ms/step - loss: 0.0903
[INFO] Saved generated images at image_at_epoch_0083.png

Epoch 85/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 1s 253ms/step - loss: 0.0872
[INFO] Saved generated images at image_at_epoch_0084.png

Epoch 86/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 258ms/step - loss: 0.0874
[INFO] Saved generated images at image_at_epoch_0085.png

Epoch 87/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 1s 260ms/step - loss: 0.0881
[INFO] Saved generated images at image_at_epoch_0086.png

Epoch 88/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.0937
[INFO] Saved generated images at image_at_epoch_0087.png

Epoch 89/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 274ms/step - loss: 0.0926
[INFO] Saved generated images at image_at_epoch_0088.png

Epoch 90/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0952
[INFO] Saved generated images at image_at_epoch_0089.png

Epoch 91/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.0892
[INFO] Saved generated images at image_at_epoch_0090.png

Epoch 92/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0875
[INFO] Saved generated images at image_at_epoch_0091.png

Epoch 93/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0895
[INFO] Saved generated images at image_at_epoch_0092.png

Epoch 94/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 266ms/step - loss: 0.0928
[INFO] Saved generated images at image_at_epoch_0093.png

Epoch 95/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0840
```

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[INFO] Saved generated images at image_at_epoch_0094.png

Epoch 96/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0935
[INFO] Saved generated images at image_at_epoch_0095.png

Epoch 97/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0815
[INFO] Saved generated images at image_at_epoch_0096.png

Epoch 98/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0872
[INFO] Saved generated images at image_at_epoch_0097.png

Epoch 99/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0860
[INFO] Saved generated images at image_at_epoch_0098.png

Epoch 100/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0886
[INFO] Saved generated images at image_at_epoch_0099.png

Epoch 101/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0843
[INFO] Saved generated images at image_at_epoch_0100.png

Epoch 102/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0867
[INFO] Saved generated images at image_at_epoch_0101.png

Epoch 103/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0850
[INFO] Saved generated images at image_at_epoch_0102.png

Epoch 104/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0817
[INFO] Saved generated images at image_at_epoch_0103.png

Epoch 105/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.0905
[INFO] Saved generated images at image_at_epoch_0104.png

Epoch 106/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0830
[INFO] Saved generated images at image_at_epoch_0105.png

Epoch 107/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0814
[INFO] Saved generated images at image_at_epoch_0106.png

Epoch 108/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 266ms/step - loss: 0.0834
[INFO] Saved generated images at image_at_epoch_0107.png
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Epoch 109/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0830
[INFO] Saved generated images at image_at_epoch_0108.png

Epoch 110/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 274ms/step - loss: 0.0831
[INFO] Saved generated images at image_at_epoch_0109.png

Epoch 111/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0791
[INFO] Saved generated images at image_at_epoch_0110.png

Epoch 112/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0798
[INFO] Saved generated images at image_at_epoch_0111.png

Epoch 113/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 1s 255ms/step - loss: 0.0786
[INFO] Saved generated images at image_at_epoch_0112.png

Epoch 114/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 1s 254ms/step - loss: 0.0875
[INFO] Saved generated images at image_at_epoch_0113.png

Epoch 115/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 262ms/step - loss: 0.0841
[INFO] Saved generated images at image_at_epoch_0114.png

Epoch 116/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.0856
[INFO] Saved generated images at image_at_epoch_0115.png

Epoch 117/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 274ms/step - loss: 0.0817
[INFO] Saved generated images at image_at_epoch_0116.png

Epoch 118/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0809
[INFO] Saved generated images at image_at_epoch_0117.png

Epoch 119/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.0820
[INFO] Saved generated images at image_at_epoch_0118.png

Epoch 120/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0833
[INFO] Saved generated images at image_at_epoch_0119.png

Epoch 121/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 274ms/step - loss: 0.0753
[INFO] Saved generated images at image_at_epoch_0120.png

Epoch 122/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0799
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[INFO] Saved generated images at image_at_epoch_0121.png

Epoch 123/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.0812
[INFO] Saved generated images at image_at_epoch_0122.png

Epoch 124/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 273ms/step - loss: 0.0755
[INFO] Saved generated images at image_at_epoch_0123.png

Epoch 125/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0792
[INFO] Saved generated images at image_at_epoch_0124.png

Epoch 126/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0798
[INFO] Saved generated images at image_at_epoch_0125.png

Epoch 127/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0795
[INFO] Saved generated images at image_at_epoch_0126.png

Epoch 128/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0774
[INFO] Saved generated images at image_at_epoch_0127.png

Epoch 129/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0794
[INFO] Saved generated images at image_at_epoch_0128.png

Epoch 130/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 273ms/step - loss: 0.0763
[INFO] Saved generated images at image_at_epoch_0129.png

Epoch 131/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0816
[INFO] Saved generated images at image_at_epoch_0130.png

Epoch 132/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 264ms/step - loss: 0.0809
[INFO] Saved generated images at image_at_epoch_0131.png

Epoch 133/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0765
[INFO] Saved generated images at image_at_epoch_0132.png

Epoch 134/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0754
[INFO] Saved generated images at image_at_epoch_0133.png

Epoch 135/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 273ms/step - loss: 0.0760
[INFO] Saved generated images at image_at_epoch_0134.png
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Epoch 136/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0757
[INFO] Saved generated images at image_at_epoch_0135.png

Epoch 137/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.0769
[INFO] Saved generated images at image_at_epoch_0136.png

Epoch 138/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0794
[INFO] Saved generated images at image_at_epoch_0137.png

Epoch 139/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 259ms/step - loss: 0.0717
[INFO] Saved generated images at image_at_epoch_0138.png

Epoch 140/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 1s 256ms/step - loss: 0.0744
[INFO] Saved generated images at image_at_epoch_0139.png

Epoch 141/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 262ms/step - loss: 0.0796
[INFO] Saved generated images at image_at_epoch_0140.png

Epoch 142/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0707
[INFO] Saved generated images at image_at_epoch_0141.png

Epoch 143/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0737
[INFO] Saved generated images at image_at_epoch_0142.png

Epoch 144/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 273ms/step - loss: 0.0739
[INFO] Saved generated images at image_at_epoch_0143.png

Epoch 145/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.0736
[INFO] Saved generated images at image_at_epoch_0144.png

Epoch 146/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0740
[INFO] Saved generated images at image_at_epoch_0145.png

Epoch 147/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0754
[INFO] Saved generated images at image_at_epoch_0146.png

Epoch 148/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0802
[INFO] Saved generated images at image_at_epoch_0147.png

Epoch 149/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0729
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[INFO] Saved generated images at image_at_epoch_0148.png

Epoch 150/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0765
[INFO] Saved generated images at image_at_epoch_0149.png

Epoch 151/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0713
[INFO] Saved generated images at image_at_epoch_0150.png

Epoch 152/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0731
[INFO] Saved generated images at image_at_epoch_0151.png

Epoch 153/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.0751
[INFO] Saved generated images at image_at_epoch_0152.png

Epoch 154/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0729
[INFO] Saved generated images at image_at_epoch_0153.png

Epoch 155/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 274ms/step - loss: 0.0707
[INFO] Saved generated images at image_at_epoch_0154.png

Epoch 156/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 273ms/step - loss: 0.0805
[INFO] Saved generated images at image_at_epoch_0155.png

Epoch 157/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0744
[INFO] Saved generated images at image_at_epoch_0156.png

Epoch 158/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 277ms/step - loss: 0.0714
[INFO] Saved generated images at image_at_epoch_0157.png

Epoch 159/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0745
[INFO] Saved generated images at image_at_epoch_0158.png

Epoch 160/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0726
[INFO] Saved generated images at image_at_epoch_0159.png

Epoch 161/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0703
[INFO] Saved generated images at image_at_epoch_0160.png

Epoch 162/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 276ms/step - loss: 0.0748
[INFO] Saved generated images at image_at_epoch_0161.png
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Epoch 163/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0718
[INFO] Saved generated images at image_at_epoch_0162.png

Epoch 164/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.0703
[INFO] Saved generated images at image_at_epoch_0163.png

Epoch 165/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0738
[INFO] Saved generated images at image_at_epoch_0164.png

Epoch 166/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0720
[INFO] Saved generated images at image_at_epoch_0165.png

Epoch 167/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0756
[INFO] Saved generated images at image_at_epoch_0166.png

Epoch 168/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0786
[INFO] Saved generated images at image_at_epoch_0167.png

Epoch 169/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0701
[INFO] Saved generated images at image_at_epoch_0168.png

Epoch 170/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0712
[INFO] Saved generated images at image_at_epoch_0169.png

Epoch 171/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0714
[INFO] Saved generated images at image_at_epoch_0170.png

Epoch 172/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0727
[INFO] Saved generated images at image_at_epoch_0171.png

Epoch 173/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0702
[INFO] Saved generated images at image_at_epoch_0172.png

Epoch 174/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0708
[INFO] Saved generated images at image_at_epoch_0173.png

Epoch 175/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 273ms/step - loss: 0.0737
[INFO] Saved generated images at image_at_epoch_0174.png

Epoch 176/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 276ms/step - loss: 0.0742
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[INFO] Saved generated images at image_at_epoch_0175.png

Epoch 177/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0719
[INFO] Saved generated images at image_at_epoch_0176.png

Epoch 178/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0763
[INFO] Saved generated images at image_at_epoch_0177.png

Epoch 179/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0705
[INFO] Saved generated images at image_at_epoch_0178.png

Epoch 180/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0740
[INFO] Saved generated images at image_at_epoch_0179.png

Epoch 181/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0737
[INFO] Saved generated images at image_at_epoch_0180.png

Epoch 182/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0729
[INFO] Saved generated images at image_at_epoch_0181.png

Epoch 183/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0690
[INFO] Saved generated images at image_at_epoch_0182.png

Epoch 184/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0670
[INFO] Saved generated images at image_at_epoch_0183.png

Epoch 185/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0658
[INFO] Saved generated images at image_at_epoch_0184.png

Epoch 186/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0690
[INFO] Saved generated images at image_at_epoch_0185.png

Epoch 187/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0669
[INFO] Saved generated images at image_at_epoch_0186.png

Epoch 188/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0730
[INFO] Saved generated images at image_at_epoch_0187.png

Epoch 189/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0735
[INFO] Saved generated images at image_at_epoch_0188.png
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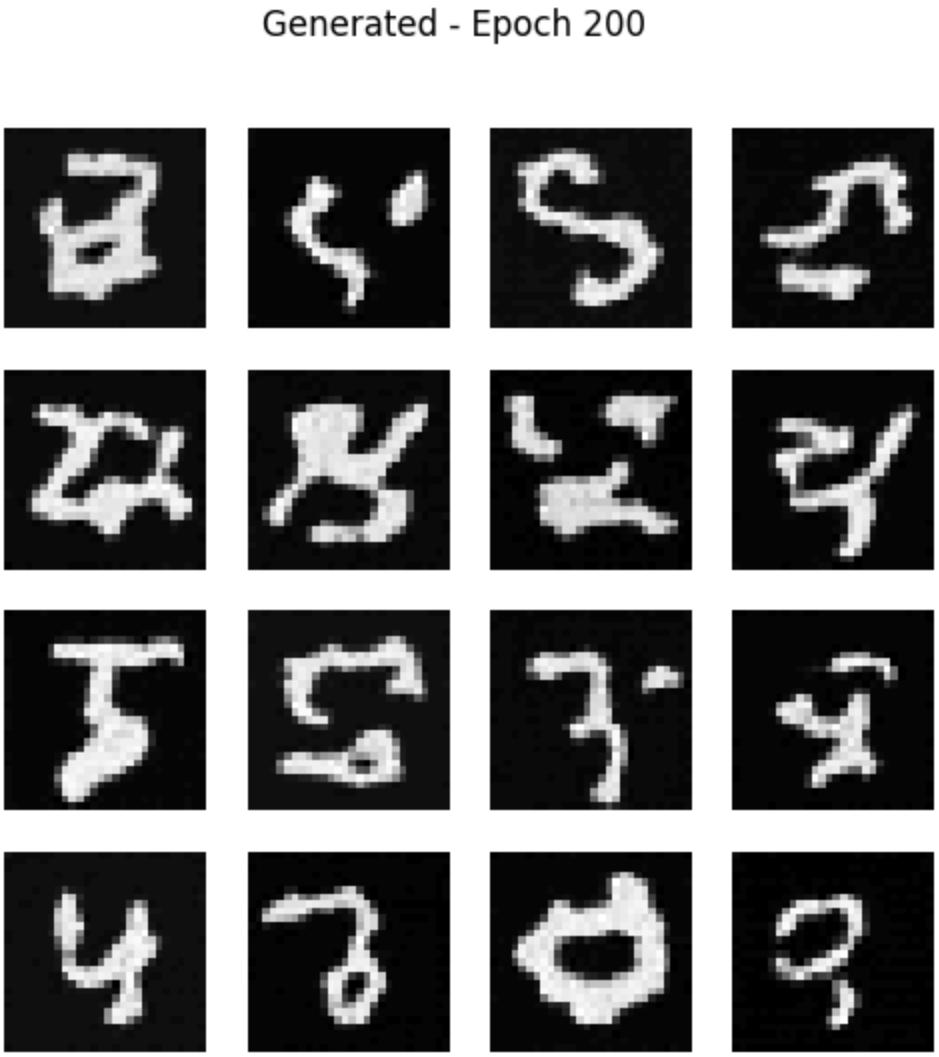
```
Epoch 190/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 273ms/step - loss: 0.0739
[INFO] Saved generated images at image_at_epoch_0189.png

Epoch 191/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 272ms/step - loss: 0.0704
[INFO] Saved generated images at image_at_epoch_0190.png

Epoch 192/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 268ms/step - loss: 0.0701
[INFO] Saved generated images at image_at_epoch_0191.png

Epoch 193/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 276ms/step - loss: 0.0692
[INFO] Saved generated images at image_at_epoch_0192.png

Epoch 194/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 274ms/step - loss: 0.0672
[INFO] Saved generated images at image_at_epoch_0193.png

Epoch 195/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 276ms/step - loss: 0.0697
[INFO] Saved generated images at image_at_epoch_0194.png

Epoch 196/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 271ms/step - loss: 0.0683
[INFO] Saved generated images at image_at_epoch_0195.png

Epoch 197/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 269ms/step - loss: 0.0698
[INFO] Saved generated images at image_at_epoch_0196.png

Epoch 198/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 275ms/step - loss: 0.0655
[INFO] Saved generated images at image_at_epoch_0197.png

Epoch 199/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 267ms/step - loss: 0.0674
[INFO] Saved generated images at image_at_epoch_0198.png

Epoch 200/200
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 270ms/step - loss: 0.0686
[INFO] Saved generated images at image_at_epoch_0199.png
```

In [18]:
```
import glob
import imageio
import os
import PIL
from IPython import display
```

In [25]:
```
PIL.Image.open('/content/image_at_epoch_0199.png')
```

Out[25]:

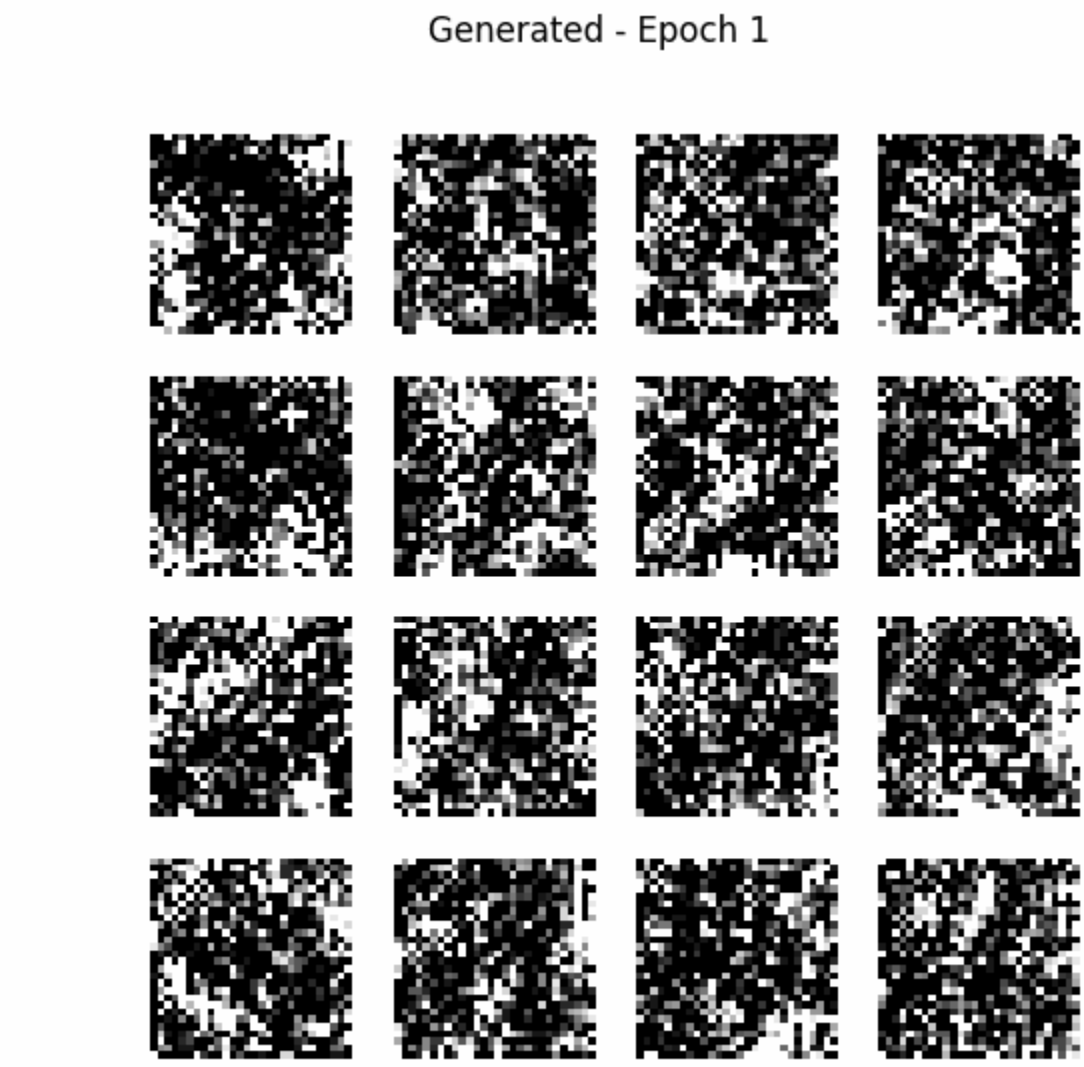


In [19]:
```
# Display a single image using the epoch number
def display_image(epoch_no):
  return PIL.Image.open('image_at_epoch_{:04d}.png'.format(epoch_no))
```

In [20]:
```
anim_file = 'diffusion_model.gif'

with imageio.get_writer(anim_file, mode='I') as writer:
  filenames = glob.glob('image*.png')
  filenames = sorted(filenames)
  for filename in filenames:
    image = imageio.imread(filename)
    writer.append_data(image)
  image = imageio.imread(filename)
  writer.append_data(image)
```

```
/tmp/ipython-input-2580269548.py:7: DeprecationWarning: Starting with ImageIO v
3 the behavior of this function will switch to that of iio.v3.imread. To keep t
he current behavior (and make this warning disappear) use `import imageio.v2 as
imageio` or call `imageio.v2.imread` directly.
  image = imageio.imread(filename)
/tmp/ipython-input-2580269548.py:9: DeprecationWarning: Starting with ImageIO v
3 the behavior of this function will switch to that of iio.v3.imread. To keep t
he current behavior (and make this warning disappear) use `import imageio.v2 as
imageio` or call `imageio.v2.imread` directly.
  image = imageio.imread(filename)
```

In [22]:
```
import tensorflow_docs.vis.embed as embed
from IPython.display import display
anim_file = '/content/diffusion_model.gif'

display(embed.embed_file(anim_file))
```



In [ ]:
```
import pickle
model.save
```