Import Library And Lock PATH

In [2]:
```
import pandas as pd
import numpy as np
from sklearn.metrics import confusion_matrix
import seaborn as sns
import matplotlib.pyplot as plt
import os
os.chdir(r"D:\ARSYAD\TelU\Semester5\KA\Tubes")
os.getcwd()
```

Out[2]: 'D:\\ARSYAD\\TelU\\Semester5\\KA\\Tubes'

Read dataset

In [3]:
```
train = pd.read_csv("dataset/train.csv", sep=';')
test  = pd.read_csv("dataset/test.csv", sep=';')
```

In [4]:
```
train.head()
```

Out[4]:

	id	age	job	marital	education	default	housing	loan	contact	month
0	1	52	technician	married	high.school	no	yes	no	cellular	nov
1	2	33	admin.	single	university.degree	no	yes	no	cellular	nov
2	5	54	admin.	single	university.degree	no	yes	no	cellular	may
3	6	53	housemaid	married	high.school	no	no	yes	cellular	jun
4	8	42	self-employed	married	university.degree	unknown	yes	no	cellular	aug

5 rows × 21 columns

In [5]:
```
test.head()
```

Out[5]:

	id	age	job	marital	education	default	housing	loan	contact
0	3	21	student	single	unknown	no	no	no	telephone
1	4	42	blue-collar	married	basic.6y	no	no	no	cellular
2	7	42	technician	married	professional.course	no	yes	no	cellular
3	9	33	services	married	professional.course	unknown	yes	no	cellular
4	13	29	unemployed	divorced	high.school	no	no	no	cellular

Mapping target String to numerik

In [6]:
```
train["y"] = train["y"].map({"yes":1, "no":0})

X = train.drop(columns=["y"])
y = train["y"]
```

In [7]:
```
from sklearn.preprocessing import LabelEncoder

X_encoded = X.copy()

for col in X_encoded.columns:
    if X_encoded[col].dtype == "object":
        X_encoded[col] = LabelEncoder().fit_transform(X_encoded[col].astype(str))
```

In [8]:
```
from xgboost import XGBClassifier

model = XGBClassifier(
    n_estimators=200,
    learning_rate=0.05,
    max_depth=6,
    subsample=0.8,
    colsample_bytree=0.8,
    random_state=42
)

model.fit(X_encoded, y)
```

Out[8]:

▾ XGBClassifier

▶ Parameters

Sorting most feature with XGboost Model

In [9]:
```
import pandas as pd
import numpy as np

importance = model.feature_importances_

feat_imp = pd.DataFrame({
    "feature": X_encoded.columns,
    "importance": importance
}).sort_values(by="importance", ascending=False)

feat_imp.head(10)
```

Out[9]:

	feature	importance
19	nr.employed	0.568669
15	emp.var.rate	0.075600
12	pdays	0.046120
14	poutcome	0.044358
17	cons.conf.idx	0.034388
18	euribor3m	0.027416
8	contact	0.026799
9	month	0.022450
5	default	0.017197
16	cons.price.idx	0.015503

Pick Top 6 features

In [10]:
```
top6 = ['nr.employed', 'emp.var.rate', 'pdays', 'poutcome', 'cons.conf.idx', 'eurib

train = pd.read_csv("dataset/train.csv", sep=';')
test  = pd.read_csv("dataset/test.csv",  sep=';')

train_sel = train[top6 + ['y']].copy()
test_sel = test[top6].copy()
```

Cleaning Numerik

In [11]:
```
num_cols = ['nr.employed', 'emp.var.rate', 'pdays', 'cons.conf.idx', 'euribor3m']

for col in num_cols:
    train_sel[col] = pd.to_numeric(train_sel[col], errors='coerce')
    test_sel[col]  = pd.to_numeric(test_sel[col], errors='coerce')
```

Check Missing Variable

In [12]:
```
train_sel[num_cols].describe()
```

Out[12]:

	nr.employed	emp.var.rate	pdays	cons.conf.idx	euribor3m
count	28645.000000	28645.000000	28645.000000	28645.000000	28645.000000
mean	5167.001431	0.081533	962.634177	-40.482845	3.621971
std	72.344892	1.574052	186.526076	4.639215	1.735531
min	4963.600000	-3.400000	0.000000	-50.800000	0.634000
25%	5099.100000	-1.800000	999.000000	-42.700000	1.344000
50%	5191.000000	1.100000	999.000000	-41.800000	4.857000
75%	5228.100000	1.400000	999.000000	-36.400000	4.961000
max	5228.100000	1.400000	999.000000	-26.900000	5.045000

Encode Poutcome to number

In [13]:
```
pout_map = {
    "nonexistent": 0,
    "failure": 1,
    "success": 2
}

train_sel['poutcome'] = train_sel['poutcome'].map(pout_map)
test_sel['poutcome']  = test_sel['poutcome'].map(pout_map)
```

In [14]:
```
train_sel['y'] = train_sel['y'].map({"no": 0, "yes": 1})
```

In [15]:
```
#Set variable for training model
top6 = ['nr.employed', 'emp.var.rate', 'pdays', 'poutcome', 'cons.conf.idx', 'eurib

X = train_sel[top6]
y = train_sel['y']
```

In [16]:
```
X.head()
```

Out[16]:

	nr.employed	emp.var.rate	pdays	poutcome	cons.conf.idx	euribor3m
0	5195.8	-0.1	999	0	-42.0	4.153
1	5195.8	-0.1	999	0	-42.0	4.076
2	5099.1	-1.8	999	0	-46.2	1.264
3	5076.2	-2.9	999	1	-40.8	1.260
4	5228.1	1.4	999	0	-36.1	4.966

In [17]:
```
y.head()
```

Out[17]:
```
0    0
1    0
2    0
3    1
4    0
Name: y, dtype: int64
```

In [18]:
```
from sklearn.model_selection import train_test_split

X_train, X_valid, y_train, y_valid = train_test_split(
    X, y, test_size=0.2, random_state=42
)
```

In [19]:
```
from sklearn.tree import DecisionTreeClassifier

model = DecisionTreeClassifier(
    criterion='entropy',
    max_depth=5,
    min_samples_split=20,
    min_samples_leaf=10,
    random_state=42
)

model.fit(X_train, y_train)
```

Out[19]:

▾ DecisionTreeClassifier

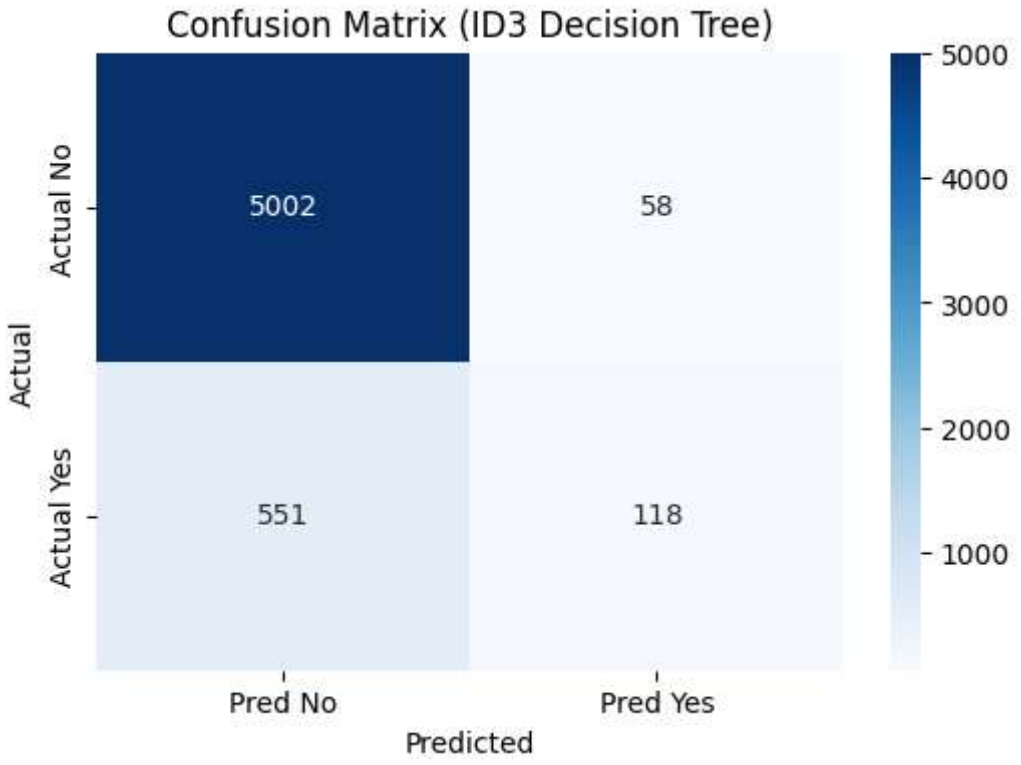
▶ Parameters

In [20]:
```
from sklearn.metrics import accuracy_score, classification_report, confusion_matrix

y_pred = model.predict(X_valid)

print("Accuracy:", accuracy_score(y_valid, y_pred))
print("\nClassification Report:\n", classification_report(y_valid, y_pred))
```

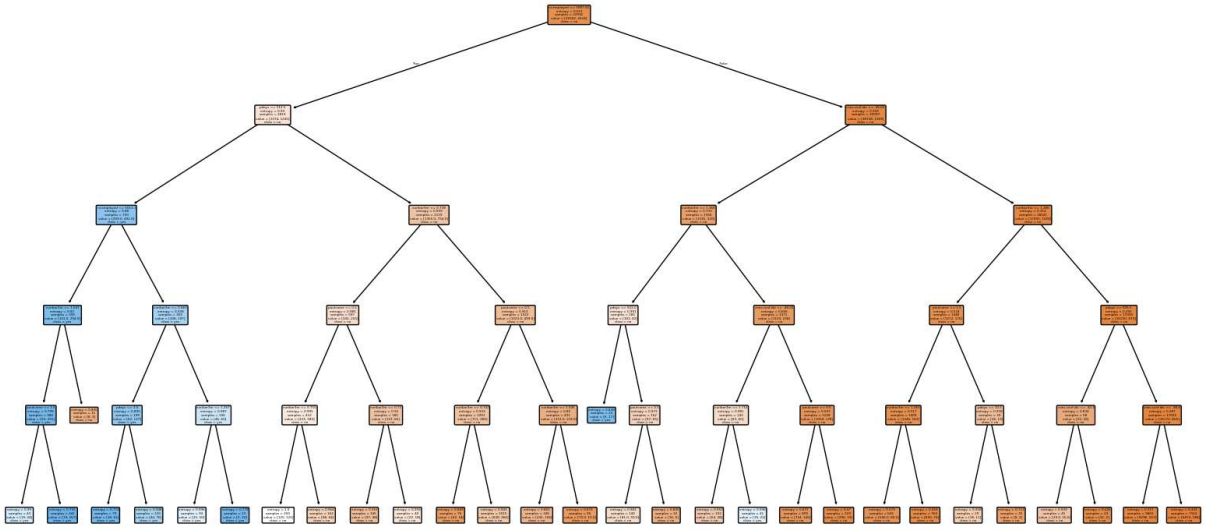
```
Accuracy: 0.8936987257811136

Classification Report:
              precision    recall  f1-score   support

           0       0.90      0.99      0.94      5060
           1       0.67      0.18      0.28       669

    accuracy                           0.89      5729
   macro avg       0.79      0.58      0.61      5729
weighted avg       0.87      0.89      0.87      5729
```

In [21]:
```
# Generate confusion matrix
cm = confusion_matrix(y_valid, y_pred)

plt.figure(figsize=(6,4))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues',
```

```
            xticklabels=["Pred No", "Pred Yes"],
            yticklabels=["Actual No", "Actual Yes"])

plt.xlabel("Predicted")
plt.ylabel("Actual")
plt.title("Confusion Matrix (ID3 Decision Tree)")
plt.show()
```



In [22]:
```
from sklearn.tree import plot_tree
import matplotlib.pyplot as plt

plt.figure(figsize=(20, 10))
plot_tree(model, feature_names=X.columns, class_names=["no","yes"], filled=True, ro
plt.show()
```

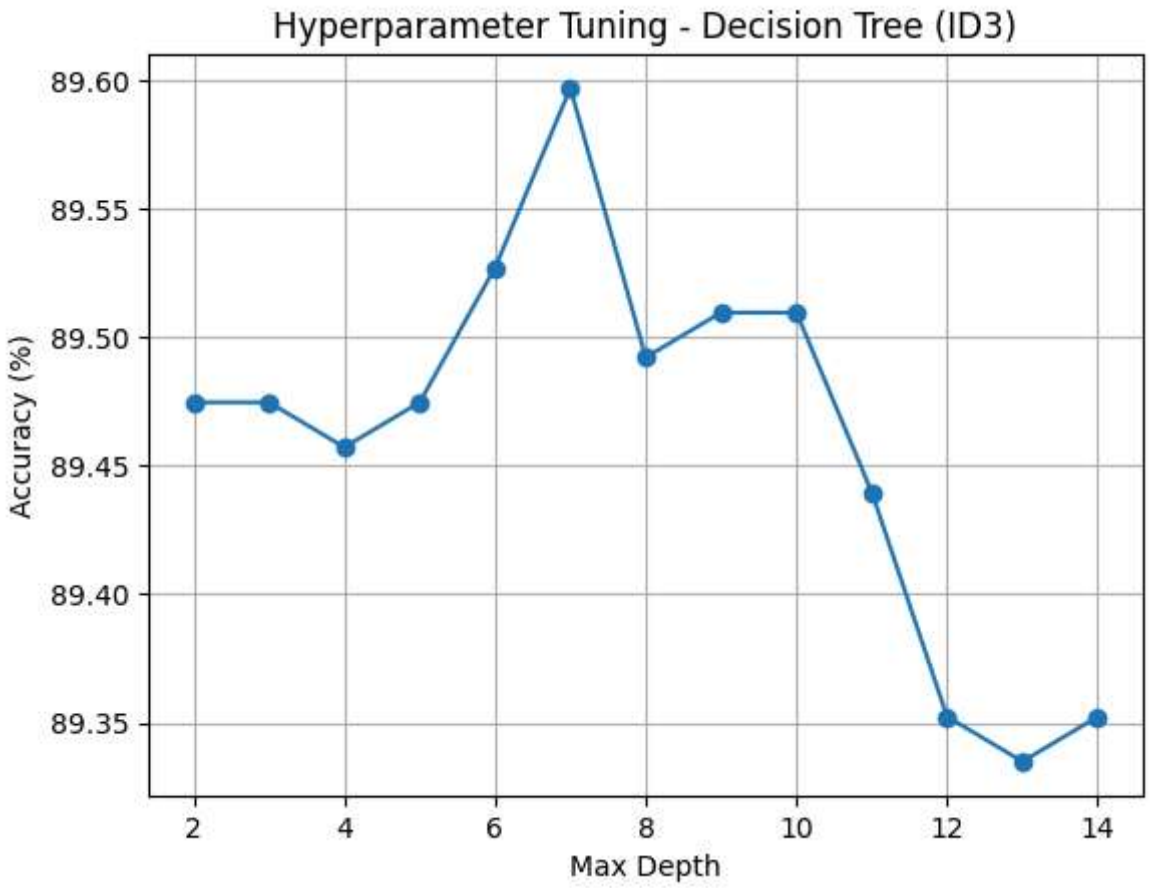


In [23]:
```
#Hyperparameter Tunning
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import accuracy_score

print("Depth | Akurasi (%)")
print("---------------------")

for d in range(2, 15):
    model = DecisionTreeClassifier(
        criterion="entropy",
        max_depth=d,
        random_state=42
    )
    model.fit(X_train, y_train)
    pred = model.predict(X_valid)
    acc = accuracy_score(y_valid, pred) * 100   # convert to percent

    print(f"{d:5d} | {acc:6.2f}%")
```

```
Depth | Akurasi (%)
---------------------
    2 |  89.47%
    3 |  89.47%
    4 |  89.46%
    5 |  89.47%
    6 |  89.53%
    7 |  89.60%
    8 |  89.49%
    9 |  89.51%
   10 |  89.51%
   11 |  89.44%
   12 |  89.35%
   13 |  89.33%
   14 |  89.35%
```

In [24]:
```
results = []
```

```
for d in range(2, 15):
    model = DecisionTreeClassifier(
        criterion="entropy",
        max_depth=d,
        random_state=42
    )
    model.fit(X_train, y_train)
    pred = model.predict(X_valid)
    acc = accuracy_score(y_valid, pred) * 100

    results.append([d, acc])

df_results = pd.DataFrame(results, columns=["max_depth", "accuracy_percent"])
df_results

plt.plot(df_results["max_depth"], df_results["accuracy_percent"], marker="o")
plt.xlabel("Max Depth")
plt.ylabel("Accuracy (%)")
plt.title("Hyperparameter Tuning - Decision Tree (ID3)")
plt.grid(True)
plt.show()
```



In [25]:
```
model_final = DecisionTreeClassifier(
    criterion='entropy',
    max_depth=7,
    min_samples_split=20,
    min_samples_leaf=10,
    random_state=42
```

```
)

model_final.fit(X_train, y_train)
```

Out[25]:

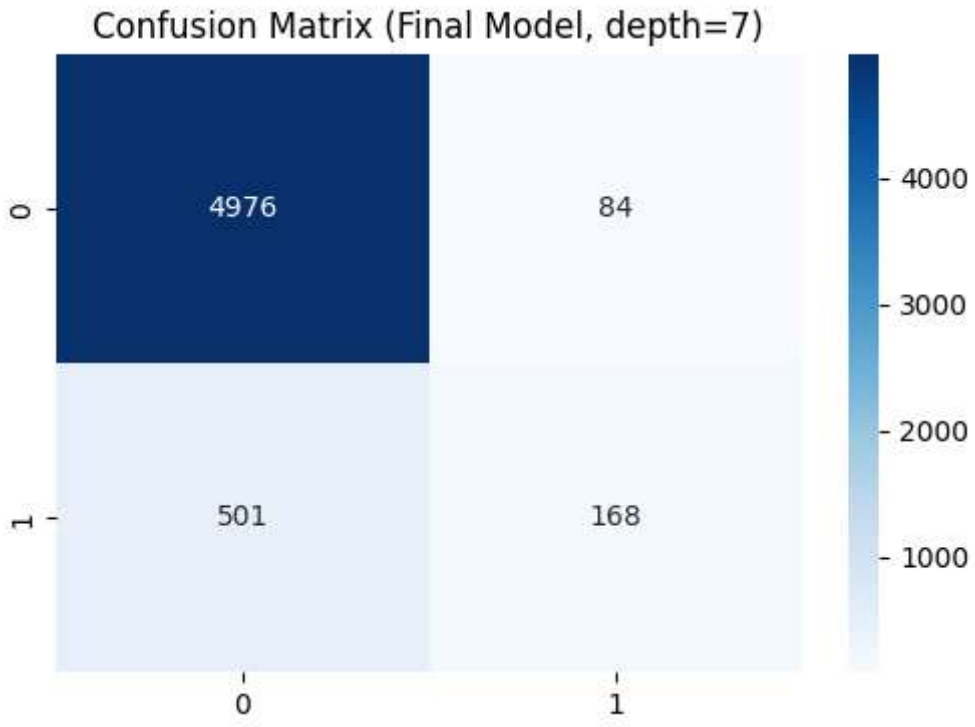
DecisionTreeClassifier

▶ Parameters

In [26]:

```
final_pred = model_final.predict(X_valid)

print("Accuracy:", accuracy_score(y_valid, final_pred))
print(classification_report(y_valid, final_pred))

from sklearn.metrics import confusion_matrix
cm = confusion_matrix(y_valid, final_pred)

plt.figure(figsize=(6,4))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title("Confusion Matrix (Final Model, depth=7)")
plt.show()
```

```
Accuracy: 0.8978879385582126
              precision    recall  f1-score   support

           0       0.91      0.98      0.94      5060
           1       0.67      0.25      0.36       669

    accuracy                           0.90      5729
   macro avg       0.79      0.62      0.65      5729
weighted avg       0.88      0.90      0.88      5729
```



Split for Genetic Algorithm

In [27]:
```
from sklearn.model_selection import train_test_split

X_tr2, X_ga, y_tr2, y_ga = train_test_split(
    X_train, y_train, test_size=0.25, random_state=42, stratify=y_train
)
```

Re-train Model for Genetic Algorithm

In [28]:
```
from sklearn.tree import DecisionTreeClassifier


model_ga = DecisionTreeClassifier(
    criterion='entropy',
    max_depth=7,
    min_samples_split=20,
    min_samples_leaf=10,
    random_state=42
)

model_ga.fit(X_tr2, y_tr2)

proba_ga = model_ga.predict_proba(X_ga)[:, 1]
proba_valid = model_ga.predict_proba(X_valid)[:, 1]
```

GA Looking for Best Treshold

In [29]:
```
import random
import numpy as np
from sklearn.metrics import f1_score, precision_score, recall_score, confusion_matr

random.seed(42)
np.random.seed(42)

def fitness_threshold(t, y_true, proba):
    y_pred = (proba >= t).astype(int)
    return f1_score(y_true, y_pred, pos_label=1)

# --- GA settings ---
POP_SIZE = 30
N_GEN = 25
ELITE = 4
MUT_RATE = 0.25
CROSS_RATE = 0.7

# init population: threshold antara 0.05 - 0.95
pop = [random.uniform(0.05, 0.95) for _ in range(POP_SIZE)]

best_t = None
best_fit = -1

for gen in range(N_GEN):
    fits = [fitness_threshold(t, y_ga, proba_ga) for t in pop]
```

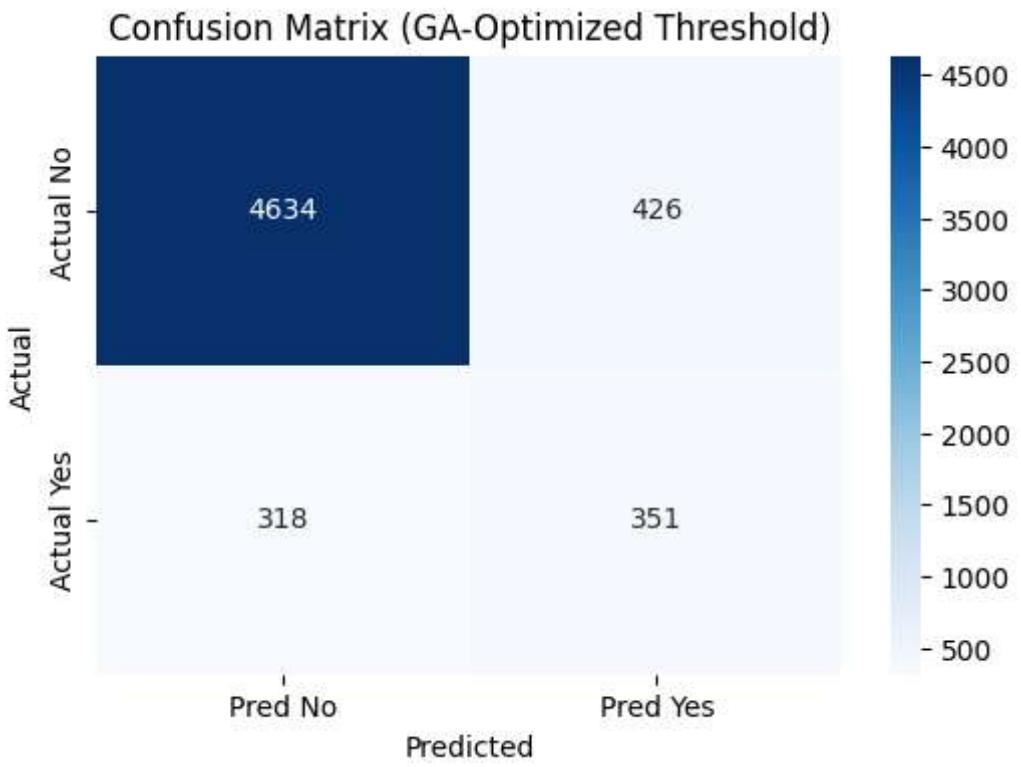
```
    # track best
    gen_best_idx = int(np.argmax(fits))
    if fits[gen_best_idx] > best_fit:
        best_fit = fits[gen_best_idx]
        best_t = pop[gen_best_idx]

    # selection: pilih elite
    elite_idx = np.argsort(fits)[-ELITE:]
    elite = [pop[i] for i in elite_idx]

    # roulette selection helper
    fit_sum = sum(fits) + 1e-9
    probs = [(f / fit_sum) for f in fits]

    def pick_one():
        r = random.random()
        s = 0.0
        for t, p in zip(pop, probs):
            s += p
            if s >= r:
                return t
        return pop[-1]

    # generate new population
    new_pop = elite.copy()

    while len(new_pop) < POP_SIZE:
        p1 = pick_one()
        p2 = pick_one()

        # crossover (blend)
        if random.random() < CROSS_RATE:
            a = random.random()
            c1 = a*p1 + (1-a)*p2
            c2 = a*p2 + (1-a)*p1
        else:
            c1, c2 = p1, p2

        # mutation (small noise)
        def mutate(x):
            if random.random() < MUT_RATE:
                x = x + random.uniform(-0.08, 0.08)
            return float(min(0.95, max(0.05, x)))

        c1 = mutate(c1)
        c2 = mutate(c2)

        new_pop.append(c1)
        if len(new_pop) < POP_SIZE:
            new_pop.append(c2)

    pop = new_pop

print(f"Best threshold from GA (on GA-val): {best_t:.3f} | Best F1(yes): {best_fit:
```

```
Best threshold from GA (on GA-val): 0.214 | Best F1(yes): 0.5038
```

In [30]:
```
# prediksi final pakai threshold terbaik
y_pred_ga = (proba_valid >= best_t).astype(int)

print("=== FINAL EVAL (GA Threshold) ===")
print("Accuracy:", f"{accuracy_score(y_valid, y_pred_ga)*100:.2f}%")
print("Precision(yes):", f"{precision_score(y_valid, y_pred_ga)*100:.2f}%")
print("Recall(yes):", f"{recall_score(y_valid, y_pred_ga)*100:.2f}%")
print("F1(yes):", f"{f1_score(y_valid, y_pred_ga)*100:.2f}%")

cm = confusion_matrix(y_valid, y_pred_ga)
print("Confusion Matrix:\n", cm)
```

```
=== FINAL EVAL (GA Threshold) ===
Accuracy: 87.01%
Precision(yes): 45.17%
Recall(yes): 52.47%
F1(yes): 48.55%
Confusion Matrix:
 [[4634  426]
 [ 318  351]]
```

In [31]:
```
import seaborn as sns
import matplotlib.pyplot as plt

plt.figure(figsize=(6,4))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues',
            xticklabels=["Pred No", "Pred Yes"],
            yticklabels=["Actual No", "Actual Yes"])
plt.title("Confusion Matrix (GA-Optimized Threshold)")
plt.xlabel("Predicted")
plt.ylabel("Actual")
plt.show()
```



In [36]:
```
X_test_final = test_sel[top6]

test_pred = model_final.predict(X_test_final)
test_pred_label = pd.Series(test_pred).map({0: "no", 1: "yes"})

submission = test.copy()
submission["y_pred"] = test_pred_label
submission.to_csv("hasil_prediksi_test.csv", index=False)
submission.head()
```

Out[36]:

	id	age	job	marital	education	default	housing	loan	contact
0	3	21	student	single	unknown	no	no	no	telephone
1	4	42	blue-collar	married	basic.6y	no	no	no	cellular
2	7	42	technician	married	professional.course	no	yes	no	cellular
3	9	33	services	married	professional.course	unknown	yes	no	cellular
4	13	29	unemployed	divorced	high.school	no	no	no	cellular

5 rows × 21 columns

In [37]:
```
submission["y_pred"].value_counts()
```

Out[37]:
```
y_pred
no     11976
yes      567
Name: count, dtype: int64
```

In [38]:
```
proba_test = model_ga.predict_proba(test_sel[top6])[:, 1]
test_pred_ga = (proba_test >= best_t).astype(int)

submission = test.copy()
submission["y_pred"] = pd.Series(test_pred_ga).map({0:"no", 1:"yes"})
submission.to_csv("hasil_prediksi_test_GA.csv", index=False)
submission.head()
```

Out[38]:

	id	age	job	marital	education	default	housing	loan	contact
0	3	21	student	single	unknown	no	no	no	telephone
1	4	42	blue-collar	married	basic.6y	no	no	no	cellular
2	7	42	technician	married	professional.course	no	yes	no	cellular
3	9	33	services	married	professional.course	unknown	yes	no	cellular
4	13	29	unemployed	divorced	high.school	no	no	no	cellular

5 rows × 21 columns

In [39]:
```
submission["y_pred"].value_counts()
```

Out[39]:
```
y_pred
no     10844
yes     1699
Name: count, dtype: int64
```