7 : Construct a Bayesian Network to demonstrate the diagnosis of heart patients using standard Heart Disease

```
# Install if the module doesn't exist
! pip install pgmpy
```

Requirement already satisfied: pgmpy in /usr/local/lib/python3.7/dist-packages (0.1.9)

Importing Heart Disease Data Set and Customizing

```python
import pandas as pd
from urllib.request import urlopen

#data_url = 'http://archive.ics.uci.edu/ml/machine-learning-databases/heart-disease/processed.hungarian.data'
data_url = 'https://tinyurl.com/processed-hungarian-data'


#names = ['age', 'sex', 'cp', 'trestbps', 'chol', 'fbs', 'restecg', 'thalach', 'exang', 'oldpeak', 'slope', 'ca', 'thal', 'heartdisease']

names = urlopen('https://tinyurl.com/names-csv').read().decode().split(',')   # need a live connection

data = urlopen(data_url)
heart_disease = pd.read_csv(data, names = names)                              # gets Cleveland data

heart_disease.head()
```

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	heartdisease
0	28	1	2	130	132	0	2	185	0	0.0	?	?	?	0
1	29	1	2	120	243	0	0	160	0	0.0	?	?	?	0
2	29	1	2	140	?	0	0	170	0	0.0	?	?	?	0
3	30	0	1	170	237	0	1	170	0	0.0	?	?	6	0
4	31	0	2	100	219	0	1	150	0	0.0	?	?	?	0

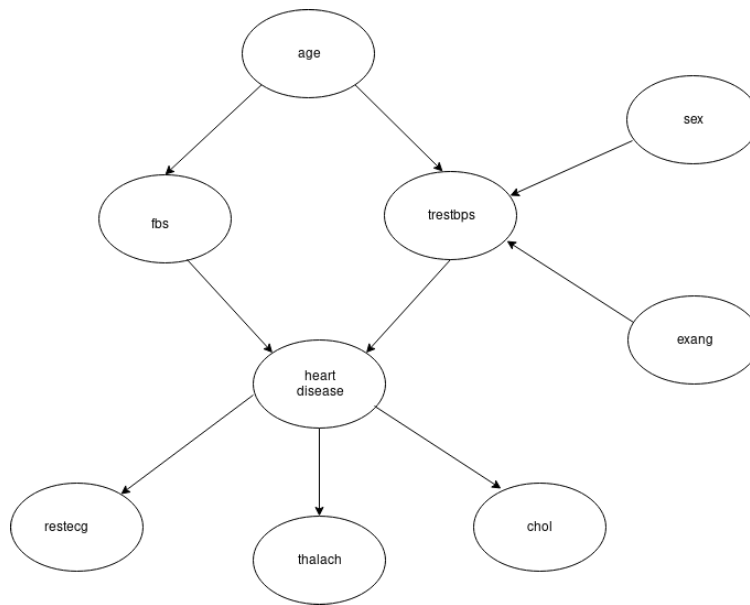### *Dropping columns which are more non numeric*

```python
heart_disease.drop(['ca', 'slope', 'thal', 'oldpeak'], axis=1)

# also replacing '?' with numpy's NaN ( not a number)

import numpy

heart_disease = heart_disease.replace('?', numpy.NaN)
```

Modeling Heart Disease Data


```python
from pgmpy.models import BayesianModel
from pgmpy.estimators import MaximumLikelihoodEstimator, BayesianEstimator

associations_list =  [
                        ('age', 'trestbps'),      ('age', 'fbs'),              ('sex', 'trestbps'),
                        ('exang', 'trestbps'),    ('trestbps','heartdisease'),('fbs','heartdisease'),
                        ('heartdisease','restecg'),('heartdisease','thalach'), ('heartdisease','chol')
                    ]
model = BayesianModel(associations_list)

# Learing CPDs using Maximum Likelihood Estimators
model.fit(heart_disease, estimator=MaximumLikelihoodEstimator)
```

```
print(model.get_cpds('age'))
```

```
+---------+---+
| age(28) | 0 |
+---------+---+
| age(29) | 0 |
+---------+---+
| age(30) | 0 |
+---------+---+
| age(31) | 0 |
+---------+---+
| age(32) | 0 |
+---------+---+
| age(33) | 0 |
+---------+---+
| age(34) | 0 |
+---------+---+
| age(35) | 0 |
+---------+---+
| age(36) | 0 |
+---------+---+
| age(37) | 0 |
+---------+---+
| age(38) | 0 |
+---------+---+
| age(39) | 0 |
+---------+---+
| age(40) | 0 |
+---------+---+
| age(41) | 0 |
+---------+---+
| age(42) | 0 |
+---------+---+
| age(43) | 0 |
+---------+---+
| age(44) | 0 |
+---------+---+
| age(45) | 0 |
+---------+---+
| age(46) | 0 |
+---------+---+
| age(47) | 1 |
+---------+---+
| age(48) | 0 |
+---------+---+
| age(49) | 0 |
+---------+---+
| age(50) | 0 |
+---------+---+
| age(51) | 0 |
+---------+---+
| age(52) | 0 |
+---------+---+
| age(53) | 0 |
+---------+---+
| age(54) | 0 |
+---------+---+
| age(55) | 0 |
+---------+---+
| age(56) | 0 |
+---------+---+
| age(57) | 0 |
+---------+---+
| age(58) | 0 |
+---------+---+
| age(59) | 0 |
+---------+---+
| age(60) | 0 |
```

```
print(model.get_cpds('sex'))
```

```
+--------+---+
| sex(0) | 0 |
+--------+---+
| sex(1) | 1 |
+--------+---+
```

```
model.get_independencies()
```

(age _|_ exang, sex)
(age _|_ exang | sex)
(age _|_ exang, sex | fbs)
(age _|_ sex | exang)
(age _|_ thalach, chol, restecg | heartdisease)
(age _|_ exang | fbs, sex)
(age _|_ thalach, chol, restecg | heartdisease, sex)
(age _|_ thalach, restecg | chol, heartdisease)
(age _|_ chol, thalach | restecg, heartdisease)
(age _|_ sex | fbs, exang)
(age _|_ thalach, chol, restecg, heartdisease | trestbps, fbs)
(age _|_ thalach, chol, restecg | fbs, heartdisease)
(age _|_ chol, restecg | thalach, heartdisease)
(age _|_ thalach, chol, restecg | exang, heartdisease)
(age _|_ thalach, chol, restecg | trestbps, heartdisease)
(age _|_ thalach, restecg | chol, heartdisease, sex)
(age _|_ chol, thalach | restecg, heartdisease, sex)
(age _|_ thalach, chol, restecg, heartdisease | trestbps, fbs, sex)
(age _|_ thalach, chol, restecg | fbs, heartdisease, sex)
(age _|_ chol, restecg | thalach, heartdisease, sex)
(age _|_ thalach, chol, restecg | heartdisease, exang, sex)
(age _|_ thalach, chol, restecg | trestbps, heartdisease, sex)
(age _|_ thalach | chol, restecg, heartdisease)
(age _|_ thalach, restecg, heartdisease | fbs, chol, trestbps)
(age _|_ thalach, restecg | fbs, chol, heartdisease)
(age _|_ restecg | chol, thalach, heartdisease)
(age _|_ thalach, restecg | chol, exang, heartdisease)
(age _|_ thalach, restecg | trestbps, chol, heartdisease)
(age _|_ chol, thalach, heartdisease | trestbps, fbs, restecg)
(age _|_ chol, thalach | fbs, restecg, heartdisease)
(age _|_ chol | thalach, restecg, heartdisease)
(age _|_ chol, thalach | restecg, exang, heartdisease)
(age _|_ chol, thalach | trestbps, restecg, heartdisease)
(age _|_ chol, restecg, heartdisease | trestbps, fbs, thalach)
(age _|_ chol, restecg | fbs, thalach, heartdisease)
(age _|_ thalach, chol, restecg, heartdisease | trestbps, fbs, exang)
(age _|_ thalach, chol, restecg | fbs, exang, heartdisease)
(age _|_ thalach, chol, restecg | trestbps, fbs, heartdisease)
(age _|_ chol, restecg | thalach, exang, heartdisease)
(age _|_ chol, restecg | trestbps, thalach, heartdisease)
(age _|_ thalach, chol, restecg | trestbps, exang, heartdisease)
(age _|_ thalach | chol, restecg, heartdisease, sex)
(age _|_ restecg, thalach, heartdisease | fbs, chol, trestbps, sex)
(age _|_ restecg, thalach | fbs, chol, heartdisease, sex)
(age _|_ restecg | chol, thalach, heartdisease, sex)
(age _|_ restecg, thalach | chol, heartdisease, exang, sex)
(age _|_ restecg, thalach | trestbps, chol, heartdisease, sex)
(age _|_ chol, thalach, heartdisease | trestbps, fbs, restecg, sex)
(age _|_ chol, thalach | fbs, restecg, heartdisease, sex)
(age _|_ chol | thalach, restecg, heartdisease, sex)
(age _|_ chol, thalach | heartdisease, restecg, exang, sex)
(age _|_ chol, thalach | trestbps, restecg, heartdisease, sex)
(age _|_ chol, restecg, heartdisease | trestbps, fbs, thalach, sex)
(age _|_ chol, restecg | fbs, thalach, heartdisease, sex)
(age _|_ restecg, chol, thalach, heartdisease | trestbps, fbs, exang, sex)
(age _|_ restecg, chol, thalach | fbs, heartdisease, exang, sex)
(age _|_ restecg, chol, thalach | trestbps, fbs, heartdisease, sex)
(age _|_ chol, restecg | heartdisease, thalach, exang, sex)
(age _|_ chol, restecg | trestbps, thalach, heartdisease, sex)
(age _|_ restecg, chol, thalach | trestbps, heartdisease, exang, sex)
(age _|_ thalach, heartdisease | fbs, chol, restecg, trestbps)
(age _|_ thalach | fbs, chol, restecg, heartdisease)
(age _|_ thalach | chol, restecg, exang, heartdisease)
(age _|_ thalach | trestbps, chol, restecg, heartdisease)
(age _|_ restecg, heartdisease | fbs, chol, thalach, trestbps)
(age _|_ restecg | fbs, chol, thalach, heartdisease)

Inferencing with Bayesian Network

```python
# Doing exact inference using Variable Elimination
from pgmpy.inference import VariableElimination
heart_disease_infer = VariableElimination(model)

# Computing the probability of bronc given smoke.
query = heart_disease_infer.query(variables=['heartdisease'], evidence={'age': 28})
print(query)
```

Finding Elimination Order: : 100%|██████████| 7/7 [00:00<00:00, 1932.99it/s]
Eliminating: restecg: 100%|██████████| 7/7 [00:00<00:00, 219.51it/s]

```
+-----------------+----------------------+
| heartdisease    |   phi(heartdisease)  |
+=================+======================+
| heartdisease(0) |               0.4919 |
+-----------------+----------------------+
| heartdisease(1) |               0.5081 |
+-----------------+----------------------+
```