In [ ]:

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Laboratory 30: Exponential, Logarithmic, Power-Law Models

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ENGR 1330 Exercise 30 - Homework

Exercise 1

The following data are the temperature as a function of vertical depth in a chemically active settling pond.

Depth (cm)	Temp (^{o}C)
0.1	21.2
0.8	27.3
3.6	31.8
12	35.6
120	42.3
390	45.9
710	47.7
1200	49.2
1800	50.5
2400	51.4

Fit the following data models.

1. Linear data model
2. Exponential data model
3. Logarithmic data model
4. Power-law model

Produce a plot of the data and data model for each model (4 plots)

Select the "best" model based on the R^2 value.

Use the best model to predict the temperature at 1 meter and 2 meters depth.

In [70]:
```
# Load the necessary packages
import numpy as np
import pandas as pd
import statistics
import math
from matplotlib import pyplot as plt
import statsmodels.formula.api as smf

df=pd.read_csv('lab30.csv')
df
```

Out[70]:

	Depth	Temp
0	0.1	21.2
1	0.8	27.3
2	3.6	31.8
3	12.0	35.6
4	120.0	42.3
5	390.0	45.9
6	710.0	47.7
7	1200.0	49.2
8	1800.0	50.5
9	2400.0	51.4

In [71]:
```
df.describe()
```

Out[71]:

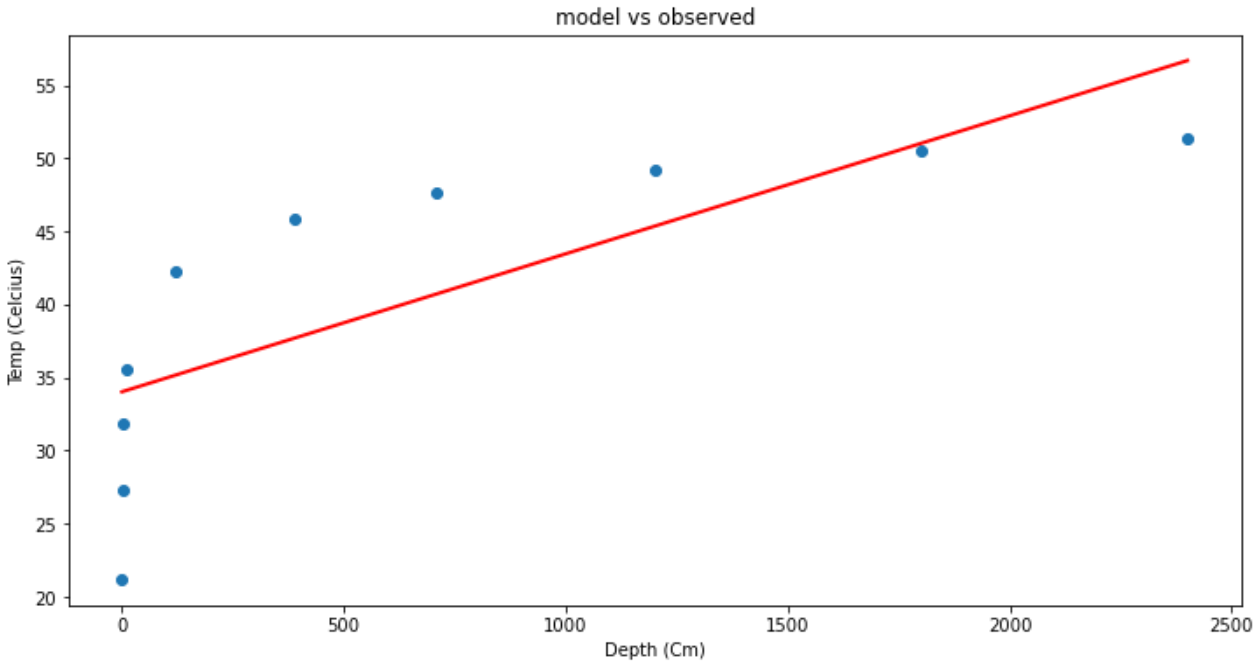
	Depth	Temp
count	10.000000	10.000000
mean	663.650000	40.290000
std	863.226788	10.670463
min	0.100000	21.200000
25%	5.700000	32.750000
50%	255.000000	44.100000
75%	1077.500000	48.825000
max	2400.000000	51.400000

In [82]:
```
# build the data lists
# build a dataframe
depth = df['Depth'].tolist()
print(depth)
temp = df['Temp'].tolist()
print(temp)
df = pd.DataFrame({'Depth':depth, 'Temp':temp})
```

```
df
print(type(df))
# Initialise and fit a linear regression model using `statsmodels`
model = smf.ols('Temp ~ Depth', data = df)
model = model.fit()
model.params
# Predict values
rsl = model.rsquared
print('The r-squared is',rsl)
yP = model.predict()

# Plot regression against actual data
plt.figure(figsize = (12, 6))
plt.xlabel('Depth (Cm)')
plt.ylabel('Temp (Celcius)')
plt.plot(df['Depth'], df['Temp'], 'o')
plt.plot(df['Depth'], yP, 'r', linewidth = 2)
plt.title('model vs observed')
plt.show()
```

```
[0.1, 0.8, 3.6, 12.0, 120.0, 390.0, 710.0, 1200.0, 1800.0, 2400.0]
[21.2, 27.3, 31.8, 35.6, 42.3, 45.9, 47.7, 49.2, 50.5, 51.4]
<class 'pandas.core.frame.DataFrame'>
The r-squared is 0.5835120068643358
```



In [84]:

```
# build the data lists
# build a dataframe
df['DDepth'] = df['Depth']** 2
df
```

Out[84]:

	Depth	Temp	DDepth
0	0.1	21.2	0.01
1	0.8	27.3	0.64
2	3.6	31.8	12.96
3	12.0	35.6	144.00

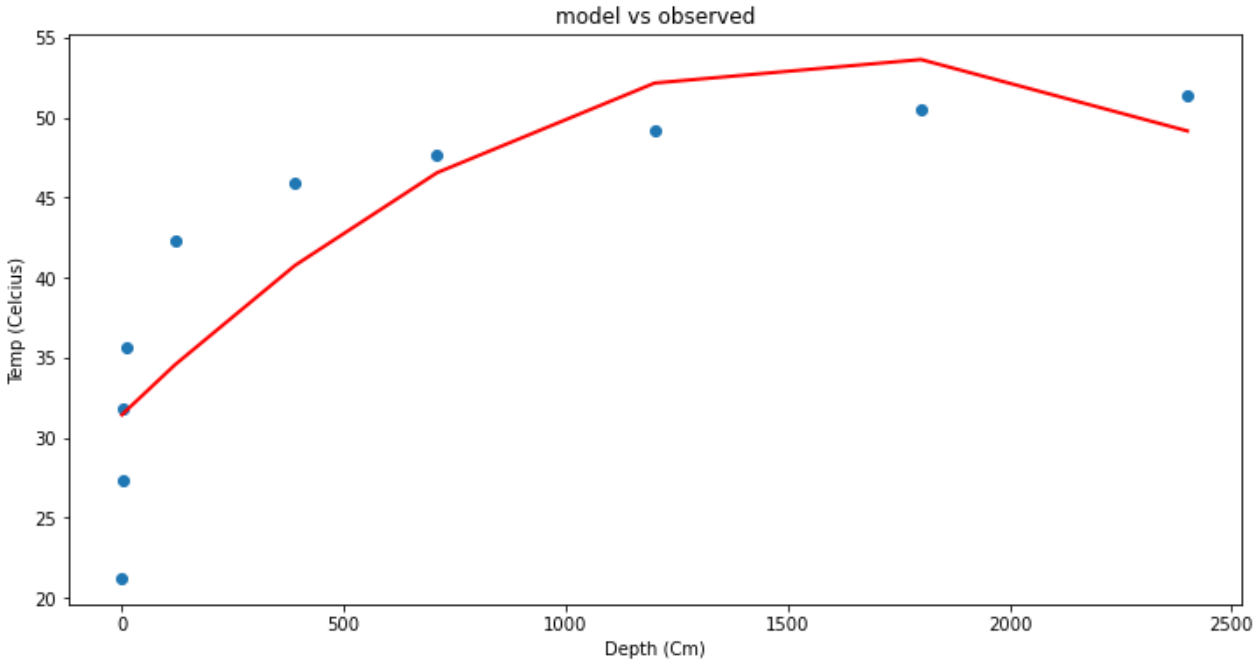
	Depth	Temp	DDepth
4	120.0	42.3	14400.00
5	390.0	45.9	152100.00
6	710.0	47.7	504100.00
7	1200.0	49.2	1440000.00
8	1800.0	50.5	3240000.00
9	2400.0	51.4	5760000.00

In [85]:
```
model = smf.ols('Temp ~ Depth + DDepth', data = df)
model = model.fit()
model.params
# Initialise and fit an exponential regression model using `statsmodels`
rsl1 = model.rsquared
print('The r-squared is',rsl1)
yP = model.predict()

# Predict values
yP = model.predict()
# Plot regression against actual data
plt.figure(figsize = (12, 6))
plt.xlabel('Depth (Cm)')
plt.ylabel('Temp (Celcius)')
plt.plot(df['Depth'], df['Temp'], 'o')
plt.plot(df['Depth'], yP, 'r', linewidth =2)

plt.title('model vs observed')
plt.show()
```

```
The r-squared is 0.7582707849296989
```



In [86]:
```
# build the data lists
dfd=pd.read_csv('lab30.csv')
dfd
```

Out[86]:

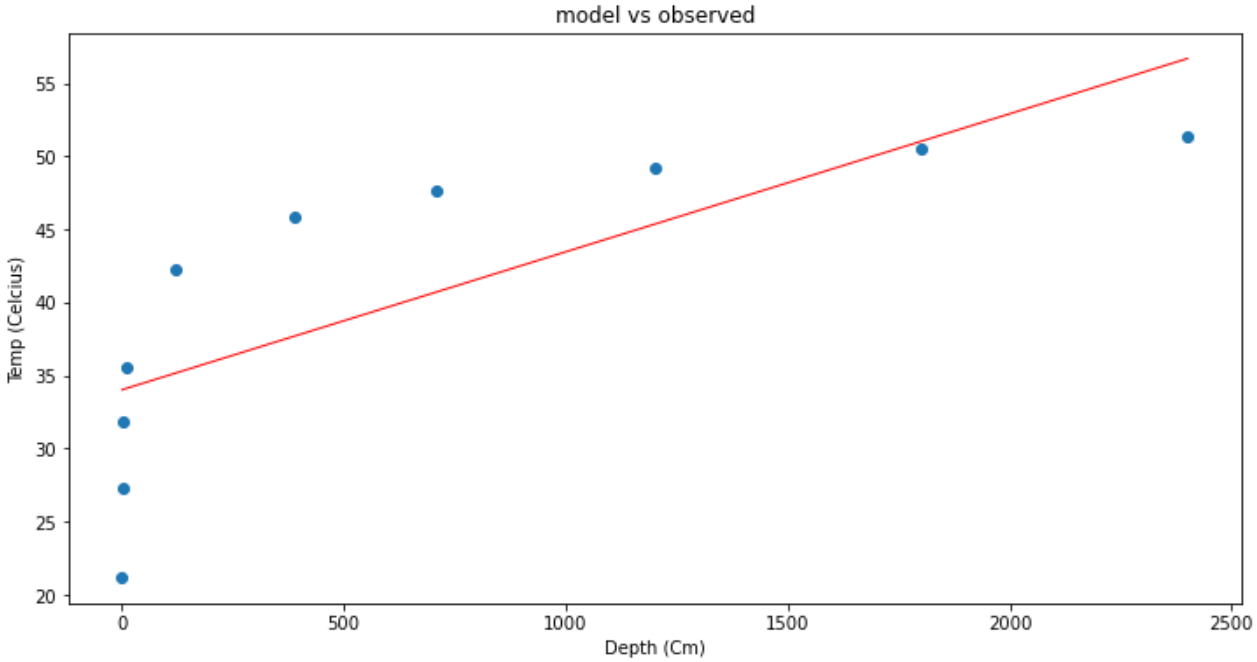
	Depth	Temp
0	0.1	21.2
1	0.8	27.3
2	3.6	31.8
3	12.0	35.6
4	120.0	42.3
5	390.0	45.9
6	710.0	47.7
7	1200.0	49.2
8	1800.0	50.5
9	2400.0	51.4

In [87]:

```
# build a dataframe
depth = dfd['Depth'].tolist()
print(depth)
temp = dfd['Temp'].tolist()
print(temp)
dfd = pd.DataFrame({'Depth':depth, 'Temp':temp})
dfd
print(type(dfd))
# Initialise and fit a linear regression model using `statsmodels`
model = smf.ols('Temp ~ Depth', data = dfd)
model = model.fit()
yppp= model.predict()
# Predict values

b0 = model.params[0]
b1 = model.params[1]
s = model.ssr
rsqE = model.rsquared
print('The R-squared is:', rsqE)
# Plot regression against actual data
plt.figure(figsize = (12, 6))
plt.xlabel('Depth (Cm)')
plt.ylabel('Temp (Celcius)')
plt.plot(dfd['Depth'], dfd['Temp'], 'o')
plt.plot(dfd['Depth'], yppp, 'r', linewidth = 1)
plt.title('model vs observed')
plt.show()
```

```
[0.1, 0.8, 3.6, 12.0, 120.0, 390.0, 710.0, 1200.0, 1800.0, 2400.0]
[21.2, 27.3, 31.8, 35.6, 42.3, 45.9, 47.7, 49.2, 50.5, 51.4]
<class 'pandas.core.frame.DataFrame'>
The R-squared is: 0.5835120068643358
```

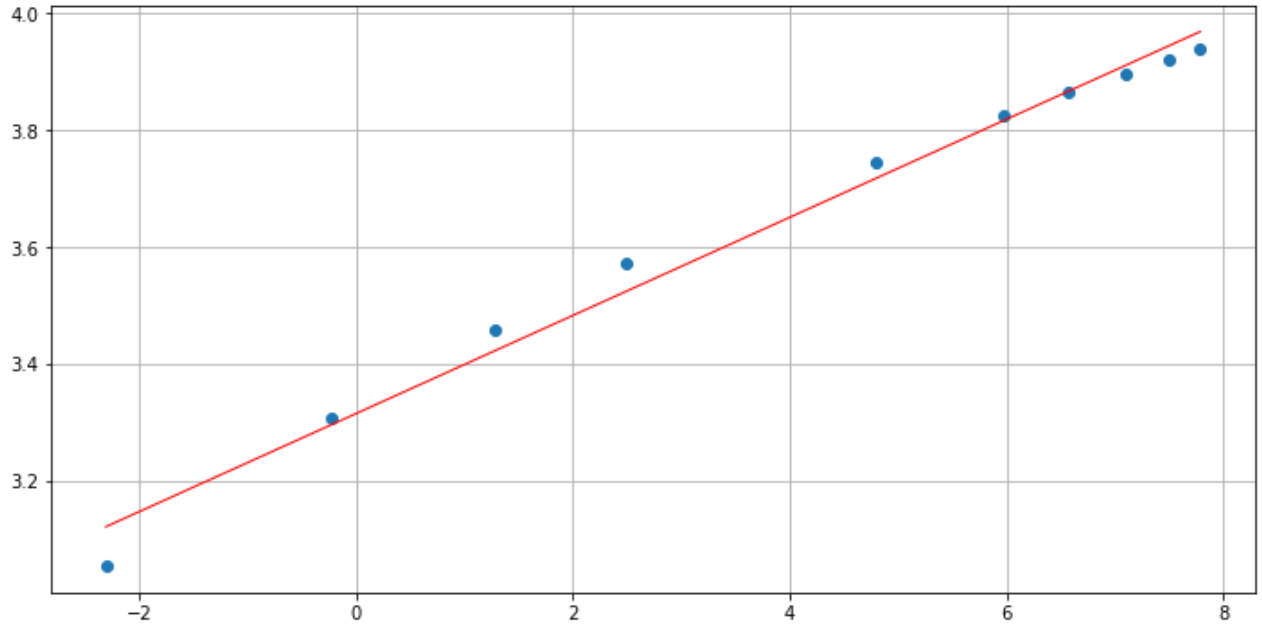


In [96]:
```
# build the data lists
# build a dataframe
from matplotlib import pyplot as plt
dfdd=pd.read_csv('lab30.csv')
dfdd
depth = dfdd['Depth'].tolist()
print(depth)
temp = dfdd['Temp'].tolist()
dfdd = pd.DataFrame({'Depth':depth, 'Temp':temp})
dfdd['lnDepth'] = dfdd['Depth'].apply(math.log)
dfdd['lnTemp'] = dfdd['Temp'].apply(math.log)
dfdd
# Initialise and fit a power-law regression model using `statsmodels`
modelplaw = smf.ols('lnTemp ~ lnDepth', data= dfdd)
modelplaw = modelplaw.fit()
# Predict values
yP = modelplaw.predict()

b0 = modelplaw.params[0]
b1 = modelplaw.params[1]
z = modelplaw.ssr
rsq = modelplaw.rsquared
print('The rSquared value is:', rsq)
# Plot regression against actual data
plt.figure(figsize = (12,6))
plt.plot(dfdd['lnDepth'], dfdd['lnTemp'], 'o')
plt.plot(dfdd['lnDepth'], yP, 'r', linewidth = 1)
plt.grid()

plt.show()
```

```
[0.1, 0.8, 3.6, 12.0, 120.0, 390.0, 710.0, 1200.0, 1800.0, 2400.0]
The rSquared value is: 0.9867519774371926
```



Choose the "good" data model

Okay the best one is clearly the power law regression model

With your "good" model answer the questions

In [ ]:
```
first = modelplaw.predict([[1],[2]])
print(first)
```

```
ERROR! Session/line number was not unique in database. History logging moved to new sess
ion 228
```

In [ ]:
```

```