# CC06 Thermal Physics Practicals

## Determination of Thermoelectric Power by using Thermocouple

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
import scipy as sp
from scipy.optimize import curve_fit
import sympy as smp
```

x_data: Temperature of hot junction.

y_data: Thermo-emf.

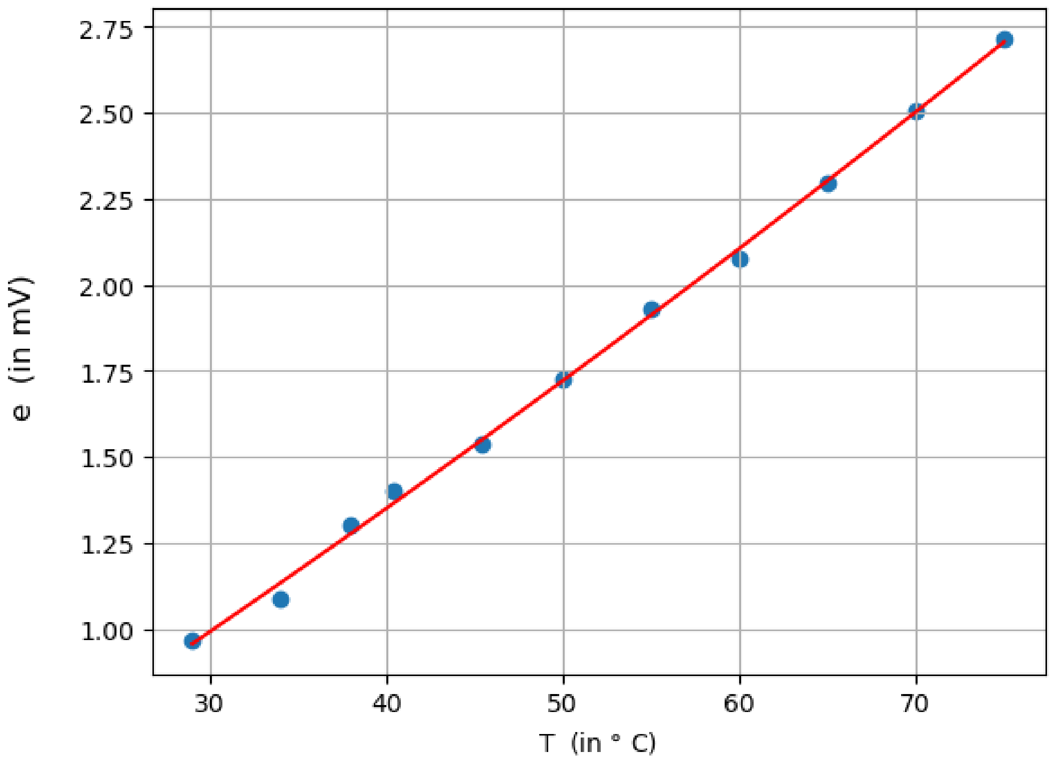
**Experiment 1**

```
x_data = np.array([25.5,31.5,42.5,46,48.5,50,51.5,53,55.5,57.5,58.5,62,63])
y_data =
np.array([0.995,1.06,1.5,1.545,1.66,1.745,1.8325,1.895,2,2.0375,2.1075,2.22,2.37])
```

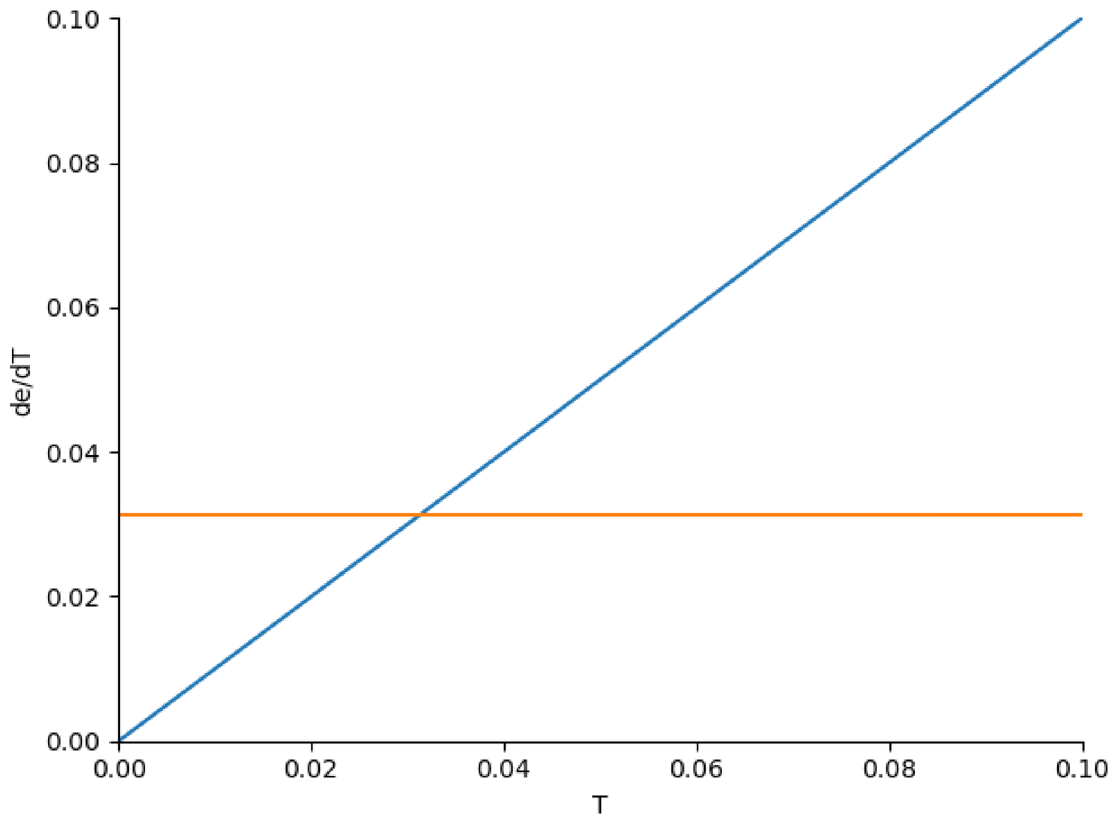
**Experiment 2** (Soumili, Satarupa, Subrata)

In [2]:
```
x_data = np.array([29,34,38,40.4,45.4,50,55,60,65,70,75])
y_data = np.array([0.965,1.085,1.3,1.4,1.535,1.725,1.93,2.075,2.295,2.505,2.715])
```

In [3]:
```python
def model_f(x, a, b, c):
    return a*(x-b)**2 + c

popt, pcov = curve_fit(model_f, x_data, y_data, p0=[1,0,0.5])
a_opt, b_opt, c_opt = popt
x_model = np.linspace(min(x_data), max(x_data), 100)
y_model = model_f(x_model, a_opt, b_opt, c_opt)

plt.scatter(x_data,y_data)
plt.plot(x_model,y_model, color='r')
plt.xlabel('T  (in $\degree$ C)')
plt.ylabel('e  (in mV) \n', fontsize=12)
plt.grid()
plt.show()

x, y = smp.symbols('x y', real=True, positive=True)
y = a_opt*(x-b_opt)**2 + c_opt
print('Equation of the curve, \t e =', y.subs(x,'T'), '\n')

print('Slope of the tangent at T = 45 is', y.diff(x).subs(x,45))
print('Slope of the tangent at T = 50 is', y.diff(x).subs(x,50))
print('Slope of the tangent at T = 36 is', y.diff(x).subs(x,40))

smp.plot(x, y.diff(x), xlim=(0,0.1), ylim=(0,0.1), xlabel='T', ylabel='de/dT')
print('Equation of the curve, \t de/dT =', y.diff(x).subs(x,'T'))
```




```
Equation of the curve,    e = 3.80003072825459*(0.00412095050590472*T + 1)**2 - 3.80
606772062052

Slope of the tangent at T = 45 is 0.0371274477798666
Slope of the tangent at T = 50 is 0.0377727778549509
Slope of the tangent at T = 36 is 0.0364821177047824
```




```
Equation of the curve,   de/dT = 0.000129066015016847*T + 0.0313194771041085
```

In [ ]:

## Lee's and Charlton's Disc Method for determining Thermal Conductivity

In [4]:
```python
import numpy as np
import matplotlib.pyplot as plt
import scipy as sp
from scipy.optimize import curve_fit
import sympy as smp
```

x_data: Time (in s).

y_data: Temperature of thermometer.

**Experiment 1**

```python
x_data = np.array([0,15,30,45,60,75,90,105,120,135,150])
y_data = np.array([95.9,95.3,94.4,93.3,92.2,91.1,89.8,88.6,87.9,86.9,85.9])
steady_theta = 90.9  # steady state temperature
```

**Experiment 2**

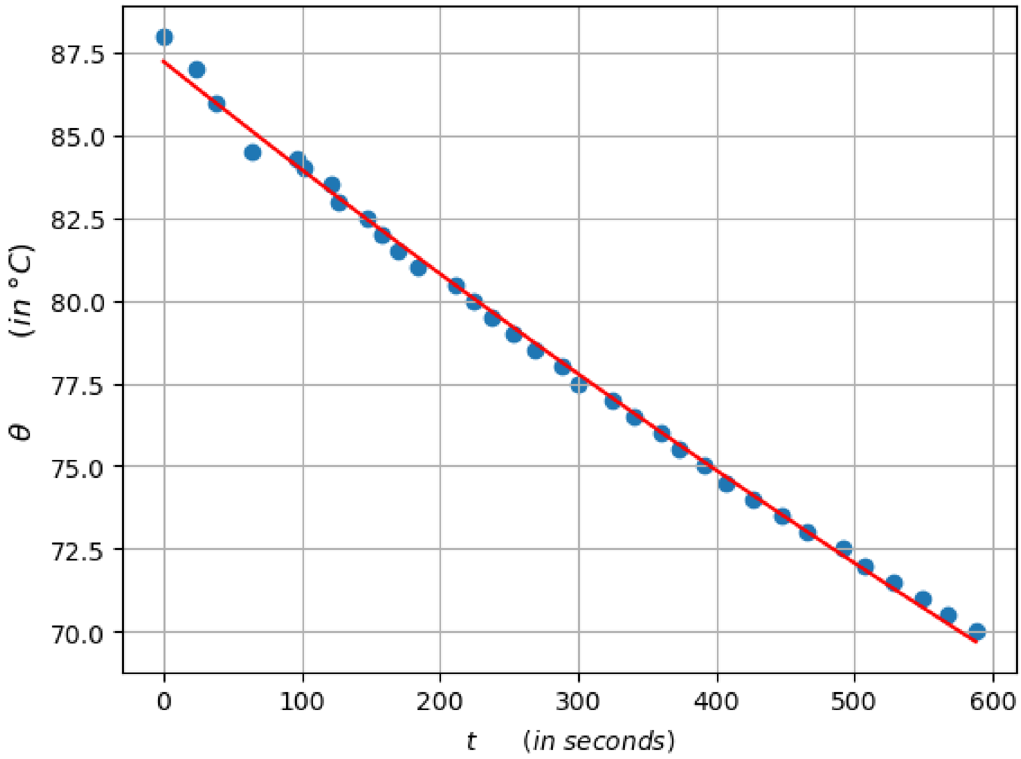
In [5]:

```
x_data = np.array([0,24,38,64,97,102,122,127,147,158,170,184,212,225,238,
253,269,289,300,325,340,360,373,392,407,426,447,466,492,507,529,549,568,588])
y_data = np.array([88,87,86,84.5,84.3,84,83.5,83,82.5,82,81.5,81,80.5,80,79.5,
79,78.5,78,77.5,77,76.5,76,75.5,75,74.5,74,73.5,73,72.5,72,71.5,71,70.5,70])
steady_theta = 78  # steadty sate temperature
```

**Experiment 3** (Rameshwar, Trisha, Soumili)

```
x_data =
np.array([2.38,3.13,3.48,4.22,4.54,5.34,6.10,6.48,7.30,8.53,9.41,10.7])*60
y_data = np.array([83,82,81,80,79,78,77,76,75,74,73,72])
steady_theta = 77.5  # steady state temperature
```

In [6]:
```
def model_f(x, a, b):
    return a*np.exp(-b*x)

popt, pcov = curve_fit(model_f, x_data, y_data, p0=[83,0.01])
a_opt, b_opt = popt
x_model = np.linspace(min(x_data), max(x_data), 100)
y_model = model_f(x_model, a_opt, b_opt)

plt.scatter(x_data,y_data)
plt.plot(x_model,y_model, color='r')
plt.xlabel('$t$ \t $(in$ $seconds)$')
plt.ylabel('$\\theta$ \t $(in$ $\degree C)$', fontsize=12)
plt.grid()
plt.show()

x, y = smp.symbols('x y', real=True, positive=True)
y = a_opt * smp.exp(-b_opt*x)
print('Equation of the curve, \t theta =', y.subs(x,'t'), '\n')

print('Slope of the tangent at theta =', steady_theta, ', is',
       y.diff(x).subs(x, smp.log(a_opt/steady_theta)))
```




```
Equation of the curve,   theta = 87.2416926381637*exp(-0.000382045667039188*t)

Slope of the tangent at theta = 78 , is -0.0333288848508190
```

In [ ]: