PROBLEMA 6.1 - NEWTON COOLING

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Resolver por los 3 métodos de Euler (simple, leapfrog, modified).

Ley de enfriamento de Newton: dinámica de cómo se enfría un sistema inicialmente a temperatura T_0 en contacto con un entorno a temperatura fija T_f.

$$\frac{dT}{dt} = K(T_a - T)$$

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
```

In [2]:
```
K = 0.05    # K/min
dt = 0.01
time = np.arange(1,100,dt)
methods = ["Simple", "Modified","Improved"]
```

In [3]:
```
Tf = int(input("fixed temperature?"))
To = int(input("initial temperature?"))
```

In [4]:
```
def euler(x, f, dt, mode):
    if mode.lower() == "simple":
        a, b, d, g = 1, 0, 0, 0
    elif mode.lower() == "modified":
        a, b, d, g = 0, 1, 0.5, 0.5
    elif mode.lower() == "improved":
        a, b, d, g = 0.5, 0.5, 1, 1

    xt = x + dt*(a*f(x) + b*f(x+f(x)*d*dt))
    return xt
```

In [5]:
```
def f(T):
    return K*(Tf-T)
```

In [6]:
```
temperatures = [[To] for _ in range(3)]
for t in time:
    for i, method in enumerate(methods):
        Ti = temperatures[i][-1]
        T_next = euler(Ti,f,dt,mode=method)
        temperatures[i].append(T_next)
```

In [7]:
```
# Remove the last element from each temperatures[i] to make their lengths equal
temperatures = [temp[:-1] for temp in temperatures]
```

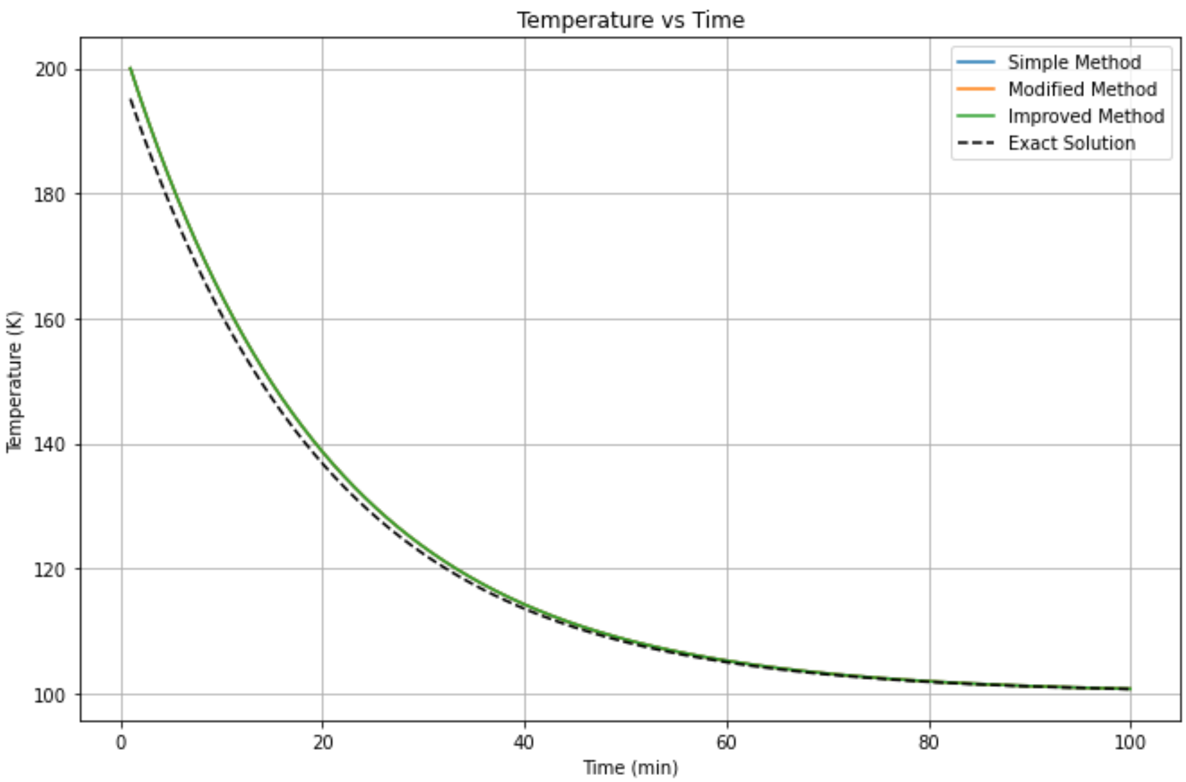
In [8]:
```
T_exact = Tf + (To-Tf)*np.exp(-K*time)
```

In [9]:
```
# Writing the output to a file
output_data = np.column_stack((time, temperatures[0], temperatures[1], temperatures
header = "Time,      Simple,      Modified,     Improved,    T_exact"
np.savetxt("6.1_output_temperatures.txt", output_data, header=header, delimiter='\t
```

In [10]:
```
# Plotting
plt.figure(figsize=(11, 7))
for i, method in enumerate(methods):
    plt.plot(time, temperatures[i], label=f"{method} Method")

plt.plot(time, T_exact, label="Exact Solution", linestyle='--', color='black')

plt.title('Temperature vs Time')
plt.xlabel('Time (min)')
plt.ylabel('Temperature (K)')
plt.legend()
plt.grid(True)
plt.show()
```



The temperature decreases exponentially, from the initial temperature to the fixed temperature.