Test 1

In [99]:
```
import pint
import math
import numpy as np
```

In [100…
```
ureg = pint.UnitRegistry(autoconvert_offset_to_baseunit = True)
```

In [101…
```
def print_msg_box(msg, indent=1, width=None, title=None):
    """Print message-box with optional title."""
    lines = msg.split('\n')
    space = " " * indent
    if not width:
        width = max(map(len, lines))
    box = f'╔{"═" * (width + indent * 2)}╗\n'  # upper_border
    if title:
        box += f'║{space}{title:<{width}}{space}║\n'  # title
        box += f'║{space}{"-" * len(title):<{width}}{space}║\n'  # underscore
    box += ''.join([f'║{space}{line:<{width}}{space}║\n' for line in lines])
    box += f'╚{"═" * (width + indent * 2)}╝'  # lower_border
    print(box)
```

Question 1: 1-23

In [102…
```
print_msg_box(f"b. Hydro")
```

```
╔══════════╗
║ b. Hydro ║
╚══════════╝
```

Question 2: 3-54

In [103…
```
alpha = 0.92
epsilon = 0.08
G_solar = 860 * ureg.W / ureg.m ** 2
h = 15 * ureg.W / (ureg.m ** 2 * ureg.degK)
T_air = 20 * ureg.degC
T_sky = 7 * ureg.degC
q_dot_net = 0
sigma = 5.67e-8 * ureg.W / (ureg.m ** 2 * ureg.K ** 4)
```

At equilibrium, $\dot{q}_{in} = \dot{q}_{out}$, then the equation becomes:

$$\alpha_s G_{solar} = \epsilon\sigma\left(T^4 - T_{sky}^4\right) + h\left(T - T_{air}\right)$$

solving for T:

$$0 = \epsilon\sigma T^4 + hT - (\alpha G_{solar} + \epsilon\sigma T_{sky}^4 + hT_{air})$$

Solving the equation for T

In [104…
```
T = np.roots([(epsilon * sigma).magnitude, 0, 0, \
              h.magnitude, -1 * \
              (alpha * G_solar + epsilon * sigma * T_sky ** 4 + h * T_air).ma
```

Answer

In [105…
```
print_msg_box(f"T_equilibrium = {round((T[-1] * ureg.K).real.to('degC'), 3)}"
```

```
T_equilibrium = 70.397 degree_Celsius
```

Question 3: 4.37

In [106…
```
A = 300_000 * ureg.meter ** 2
N = 0.18
```

Miami

In [107…
```
G_solar = 17.380 * ureg.MJ / ureg.m ** 2
```

In [108…
```
W_mia = N * A * G_solar * 365
# W_mia.to('GWh')
```

In [109…
```
print_msg_box(f"MIA Electric Potential = {round(W_mia.to('GWh'), 3)} per year
```

```
MIA Electric Potential = 95.156 gigawatt_hour per year
```

Atlanta

In [110…
```
G_solar = 16.43 * ureg.MJ / ureg.m ** 2
```

In [111…
```
W_atl = N * A * G_solar * 365
```

In [112…
```
print_msg_box(f"ATL Electric Potential = {round(W_atl.to('GWh'), 3)} per year
```

```
ATL Electric Potential = 89.954 gigawatt_hour per year
```

Question 4: 5.28

In [113…
```
N = 40
v_bar = 7.2 * ureg.mps
D = 18 * ureg.meter
N_eff = 0.33
Opp_time = 6000 * ureg.hour / ureg.year
elec_price = 0.075 / ureg.kWh
Cost_T = 1_200_000
d_air = 1.18 * ureg.kg / ureg.m ** 3
```

For a Single Turbine

In [114…
```
A = math.pi * D ** 2 / 4
W_dot_available = 1 / 2 * d_air * A * v_bar ** 3
W_dot_available = W_dot_available.to('kW')
W_dot_available
```

Out[114… 56.038227822118905 kilowatt

In [115…
```
W_dot_elec = N_eff * W_dot_available
W_dot_elec
```

Out[115… 18.49261518129924 kilowatt

In [116…
```
W_year = W_dot_elec * Opp_time
W_year.to('MWh/year')
```

Out[116… 110.95569108779544 megawatt_hour/year

In [117…
```
rev_net = W_year * elec_price
rev_net = rev_net.to('1/year')
rev_net
```

Out[117… 8321.676831584657 1/year

Multiplying by 40 Turbines

In [118…
```
ann_rev = rev_net * N
ann_rev
```

Out[118… 332867.07326338626 1/year

In [119…
```
break_even_time = Cost_T / ann_rev
print_msg_box(f"Break-even Time = {round(break_even_time, 3)}")
```

```
Break-even Time = 3.605 year
```