In [1]:
```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from scipy import stats
```

Question 1

Δh = h2-h1, measured in unit of m.

Area = πr^2, measured in unit of m^2.

The specific discharge =$\frac{Q}{A}$ measured in unit of ms^{-1}.

(a)

In [2]:
```python
# experiment number
Test=[i for i in range(1,11)]
Test=np.array(Test)

# create sediment samples
Sediment_Sample=np.array(['A','A','A','A','A','B','B','B','B','B'])

# array of flow rate
Q=np.array([2.5e-5,4e-5,5.2e-5,8e-5,1e-4,2.5e-6,4e-6,5.2e-6,8e-6,1e-5])

# head values in metre
h1=1e-2*np.array([1,2,2.5,3.4,5,0.5,1.2,3.2,5.3,6])
h2=np.around(h1, decimals=5)

h2=1e-2*np.array([4.5,6,8.5,11.6,15.5,13.5,27.2,31.2,46.3,71])
h2=np.around(h2, decimals=5)

# compute delta_h
delta_h=h2-h1
delta_h=np.around(delta_h,decimals=8)

# initialize dl
dl=0.1

# compute head gradient
dh_dl=delta_h/dl

# calulate the area
Area=np.pi*0.1*0.1

# compute specific discharge
q=Q/Area
q=np.around(q,decimals=10)

```

In [3]:
```python
# Create a table

df=pd.DataFrame(data=np.column_stack((Test,Sediment_Sample,Q,h1,h2,dh_dl,q)),\
                columns=['Test','Sample','Q ($m^{3}s^{-1}$)','h1($m$)','h2($m$)',\
                         'delta h / dl','Specific Discharge ($ms^{-1}$)'])

df['delta h / dl']=df['delta h / dl'].astype(float)
df['Specific Discharge ($ms^{-1}$)']=df['Specific Discharge ($ms^{-1}$)'].astype(float)
```

In [4]:
```python
# Display the table
df
```

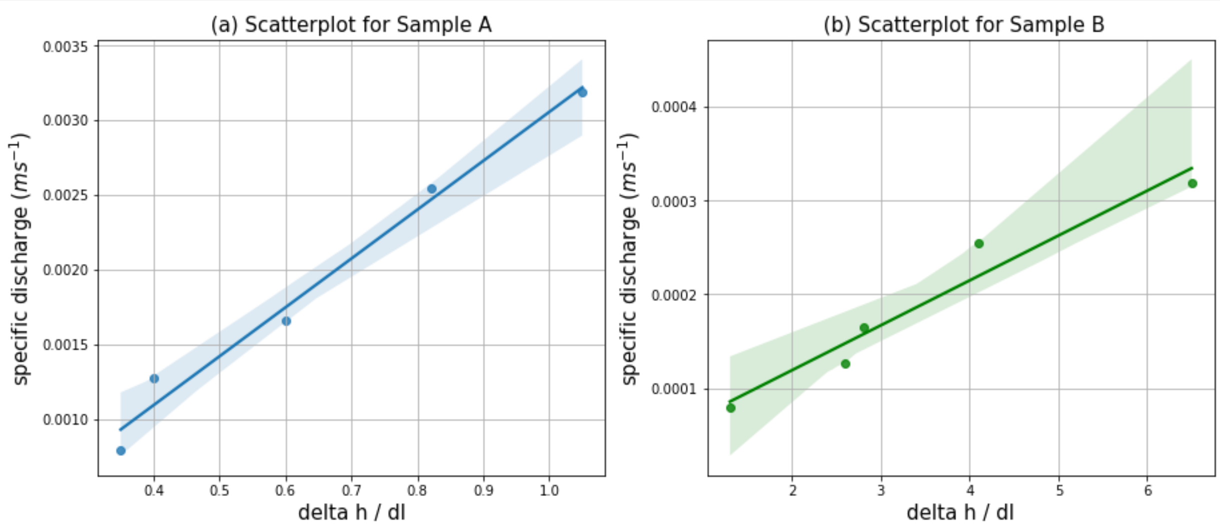
Out[4]:

	Test	Sample	Q ($m^3 s^{-1}$)	h1(m)	h2(m)	delta h / dl	Specific Discharge (ms^{-1})
0	1	A	2.5e-05	0.01	0.045	0.35	0.000796
1	2	A	4e-05	0.02	0.06	0.40	0.001273
2	3	A	5.2e-05	0.025	0.085	0.60	0.001655
3	4	A	8e-05	0.034	0.116	0.82	0.002546
4	5	A	0.0001	0.05	0.155	1.05	0.003183
5	6	B	2.5e-06	0.005	0.135	1.30	0.000080
6	7	B	4e-06	0.012	0.272	2.60	0.000127
7	8	B	5.2e-06	0.032	0.312	2.80	0.000166
8	9	B	8e-06	0.053	0.463	4.10	0.000255
9	10	B	1e-05	0.06	0.71	6.50	0.000318

In [5]:
```python
# split dataframe into sample A and B

Exp_A = df.loc[df["Sample"] == "A"]
Exp_B = df.loc[df["Sample"] == "B"]
```

(b)

In [6]:
```python
# Visualisation

plt.figure(figsize=(15,6))
plt.subplot(1,2,1)
sns.regplot(x='delta h / dl', y='Specific Discharge ($ms^{-1}$)',data=Exp_A)
plt.title(" (a) Scatterplot for Sample A ",fontsize=15)
plt.ylabel("specific discharge ($ms^{-1}$)",fontsize=15)
plt.xlabel("delta h / dl",fontsize=15)
plt.grid()

plt.subplot(1,2,2)
sns.regplot(x='delta h / dl', y='Specific Discharge ($ms^{-1}$)', data = Exp_B, color="g")
plt.title(" (b) Scatterplot for Sample B",fontsize=15)
plt.ylabel("specific discharge ($ms^{-1}$)",fontsize=15)
plt.xlabel("delta h / dl",fontsize=15)
plt.grid()
plt.show()
```



(c)

In [7]:
```python
# Slopes
stats_A= stats.linregress(Exp_A['delta h / dl'], Exp_A['Specific Discharge ($ms^{-1}$)'])
print(f"The K value for sample A is {stats_A[0]} m/s")
```

```
The K value for sample A is 0.003267371621086932 m/s
```

In [8]:
```
stats_B= stats.linregress(Exp_B['delta h / dl'], Exp_B['Specific Discharge ($ms^{-1}$)'])
print(f"The K value for sample B is {stats_B[0]} m/s")
```

```
The K value for sample B is 4.7767027239865744e-05 m/s
```

(d)

Sample A with $K \approx 10^{-3}$ is gravel

Sample B with $K \approx 10^{-5}$ is Clean Sand.

Some potential sources of error are

1. Unstable environmental conditions
2. Contamination of the sample by foreign particles or substances
3. Improperly calibrated instruments
4. Inaccurate flow measurements
5. Poorly maintained or malfunctioning equipment