Theory

In an Atwood machine two masses are connected by a string over a pulley. When the masses are unequal, the difference in their weights produces a net force which causes both masses to accelerate uniformly. Applying Newton's second law to each mass gives the theoretical acceleration of the ideal system:

$$a = \frac{(m_1 - m_2)g}{m_1 + m_2}$$

This result assumes a massless string, a frictionless axle and a pulley with negligible rotational inertia. In the real apparatus the pulley bearings and axle produce additional resistance which reduces the measured acceleration below the ideal value.

$$a = \frac{(m_1 - \Delta m - m_2)g}{m_1 + m_2}$$

Experimental Procedure

The Atwood machine was set up with a PASCO Capstone system. The mass m_2 was kept constant at 0.025 kg and the mass m_1 was varied by adding different masses. For each configuration, velocity vs time data was collected and a linear fit was used to obtain the acceleration. The mass difference required to produce approximately zero acceleration was measured to be about $\Delta m \approx 0,01 kg$, which represents frictional and inertial losses in the pulley system.

Results

m1 (kg)	m2 (kg)	Measured a (m/s²)	Ideal a (m/s²)	Corrected a (m/s²)
0,029	0,025	0,678	0,73	-1,09
0,034	0,025	1,36	1,49	-0,17
0,026	0,025	0,238	0,192	-1,73
0,074	0,025	4,56	4,85	3,86
0,124	0,025	5,25	6,51	5,86

The measured acceleration shows strong deviation from the ideal model at low mass differences. The corrected friction/inertia model using $\Delta m = 0.010$ kg predicts the high-mass behavior significantly better than the ideal model and matches the trend of collapse for small mass differences.

Uncertainty

Run 1: $a = 0,678 \pm 0,010 m/s^2$

Run 2: $a = 1,36 \pm 0,092 m/s^2$

Run 3: $a = 0,238 \pm 0,0047 m/s^2$

Run 4: $a = 4,56 \pm 0,92 m/s^2$

Run 5: $a = 5,25 \pm 0,14 m/s^2$

Conclusion

The results showed that the measured acceleration strongly deviated from the ideal theoretical values when the mass difference between the two sides was small. The real apparatus had significant friction and pulley inertia, which can be represented as an effective mass offset of approximately $\Delta m = 0.010$ kg. When this correction was included, the theoretical model agreed much better with the measurements, especially for the larger mass differences. Therefore, the corrected model describes the behavior of the system more realistically than the ideal model. Newton's Second Law remains valid, but ideal assumptions do not hold for this specific experimental setup.