Section 10

Reduced Gravity Environment of Ground-based Facilities

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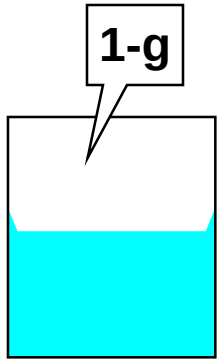
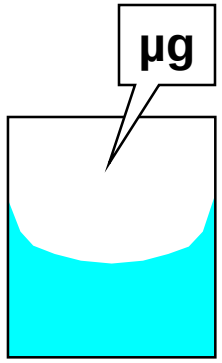
Topics for Discussion

- **Ground-based facilities**
  - **2.2 Second Drop Tower, NASA GRC**
  - **Zero Gravity Research Facility, NASA GRC**
  - **Materials Science Drop Tube, NASA MSFC**
  - **ZARM Drop Tower, University of Bremen, Germany**
  - **JAMIC Drop Tower, Japan**
- **Accelerometer systems used to measure the environment**
  - **SAMS-FF (SAMS-Free Flyer)**
  - **ZARM accelerometer**

Drop Towers & Tubes



- **Microgravity condition due to free fall**
  - **Gravity effects when a force tries to disturb free fall**
    - For example, a beaker holding a fluid exerts force on fluid
    - In free fall, beaker is falling with the fluid and surface tension & capillary forces are 'revealed'



- **Drop towers attempt to minimize external forces**
  - **Keys for a 'quiet' drop**
    - Smooth release mechanism to minimize vibration
    - Structural relaxation depends on design of carrier and experiment
    - Moving parts dynamically balanced
  - **Air drag is a large external force**
    - Steady force which gradually increases with increasing velocity
    - Several mechanisms are used to counteract air drag

Air Drag Reduction

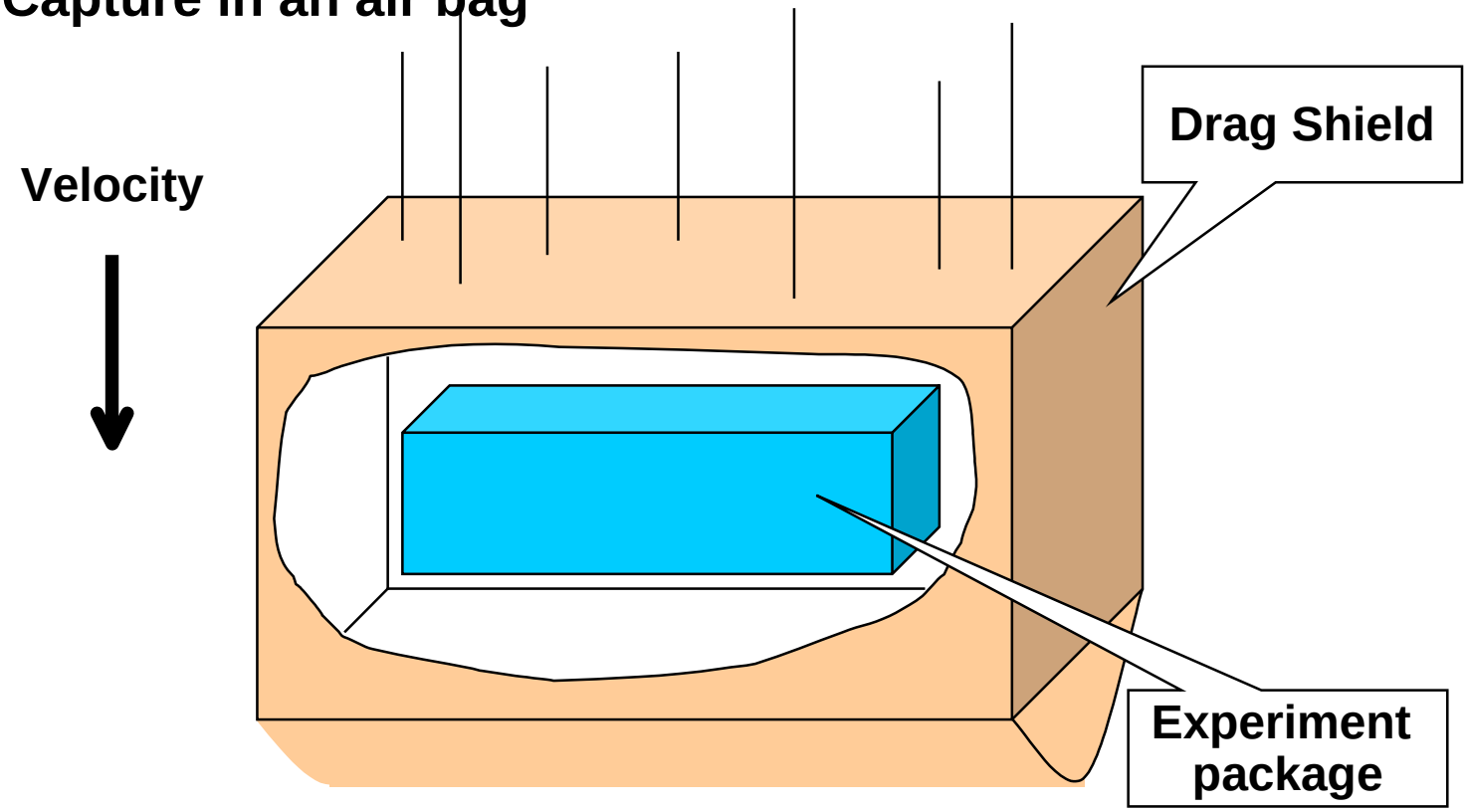
- **Air drag is a large force in a microgravity drop tower**
  - **Force is proportional to square of velocity**

$$D = {}^{1}/_{2}\,\rho\, v^2\, A\, C_d$$

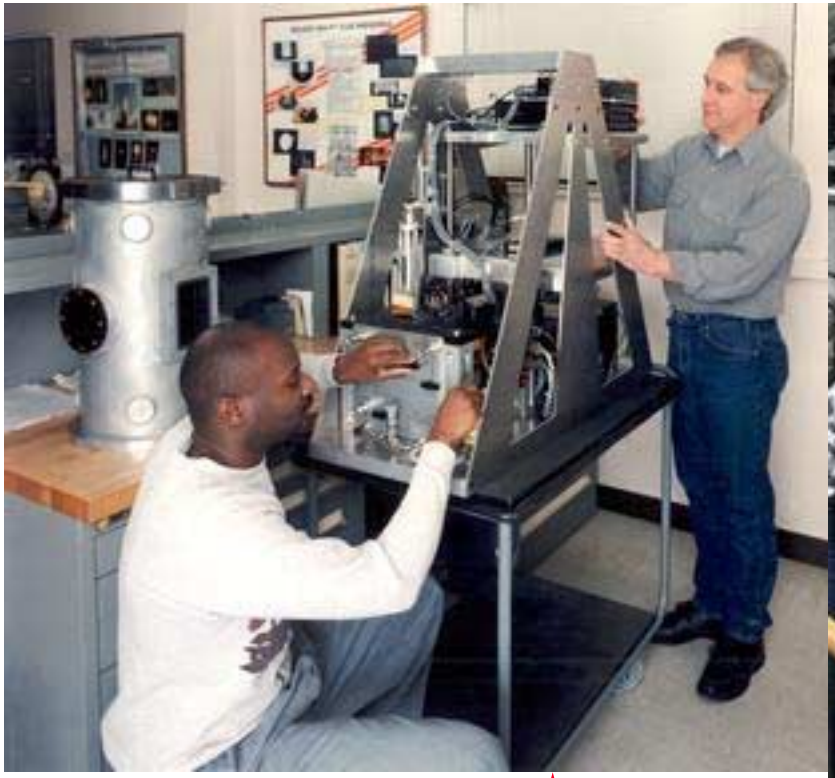
- **Methods of drag reduction**
  - **Drag shield**
    - Experiment package surrounded by free falling container
  - **Vacuum operation**
    - Evacuate the chamber in which the experiment is dropped
  - **Drag force compensation**
    - Apply compensating force to experiment carrier

Drag Shield

- **NASA GRC 2.2 Second Drop Tower uses a drag shield**
- **Capture in an air bag**



Reduced Gravity Environment of Ground-based Facilities



Experiment rig

Drag shield

Vacuum Operation

- **Vacuum drop towers include:**
  - **Zero Gravity Research Facility at NASA GRC**
    - Capture in foam pellet container
  - **ZARM facility at University of Bremen, Germany**
    - Capture in foam pellet container
  - **Materials Science Drop Tube, NASA MSFC**
    - Capture on padded surface

Experiment capture in Zero Gravity Research Facility

ZARM tower exterior

Drag Force Compensation

- **Japan Microgravity Center**
  - **Inner & outer capsule (i.e. drag shield)**
    - Vacuum drawn between inner & outer capsules
  - **Acceleration added to outer capsule for drag compensation**
    - Cold-gas jet
  - **10 seconds of microgravity with 10^{-5} g**
  - **Capture accomplished with air pressure then mechanical brake**

JAMIC

Drop Tower Comparison

- **NASA GRC 2.2 Second Drop Tower**
  - **2.2 seconds 24.1 m 10^{-4} g**
- **NASA MSFC Drop Tube**
  - **4.6 seconds 105 m 10^{-5} g**
- **ZARM Drop Tower**
  - **4.74 seconds 123 m 10^{-5} g**
- **NASA GRC Zero Gravity Research Facility**
  - **5.18 seconds 145 m 10^{-5} g**
- **Japan Microgravity Center**
  - **10 seconds 490 m 10^{-5} g**

Acceleration Environment

- **Major 1-g transition to sub-milli-g level**
  - **Figures 10-1 and 10-2**
- **Vibrations from release mechanism**
- **Vibrations due to structural 'relaxation'**
  - **Figure 10-1**
- **Vibrations from equipment operation**
  - **Figure 10-3**
- **High level deceleration at initiation of capture**
  - **Figure 10-4**

References

- **Zero Gravity Research Facility**
  - http://zeta.lerc.nasa.gov/facility/zero.htm
- **2.2 Second Drop Tower**
  - http://zeta.lerc.nasa.gov/facility/_DTOWER.HTM
- **ZARM Drop Tower**
  - http://www.zarm.uni-bremen.de/main.htm
  - ZARM Drop Tower Bremen - Users Manual, Version 28, April 2000
- **JAMIC Drop Tower**
  - http://www.jamic.co.jp/ENG/JAMIC/3.html
- **MSFC Materials Science Drop Tube**
  - http://science.msfc.nasa.gov/ssl/msad/dtf/test/tube1.htm
- **General Summary**
  - http://microgravity.msfc.nasa.gov/NASA_Carrier_User_Guide.pdf

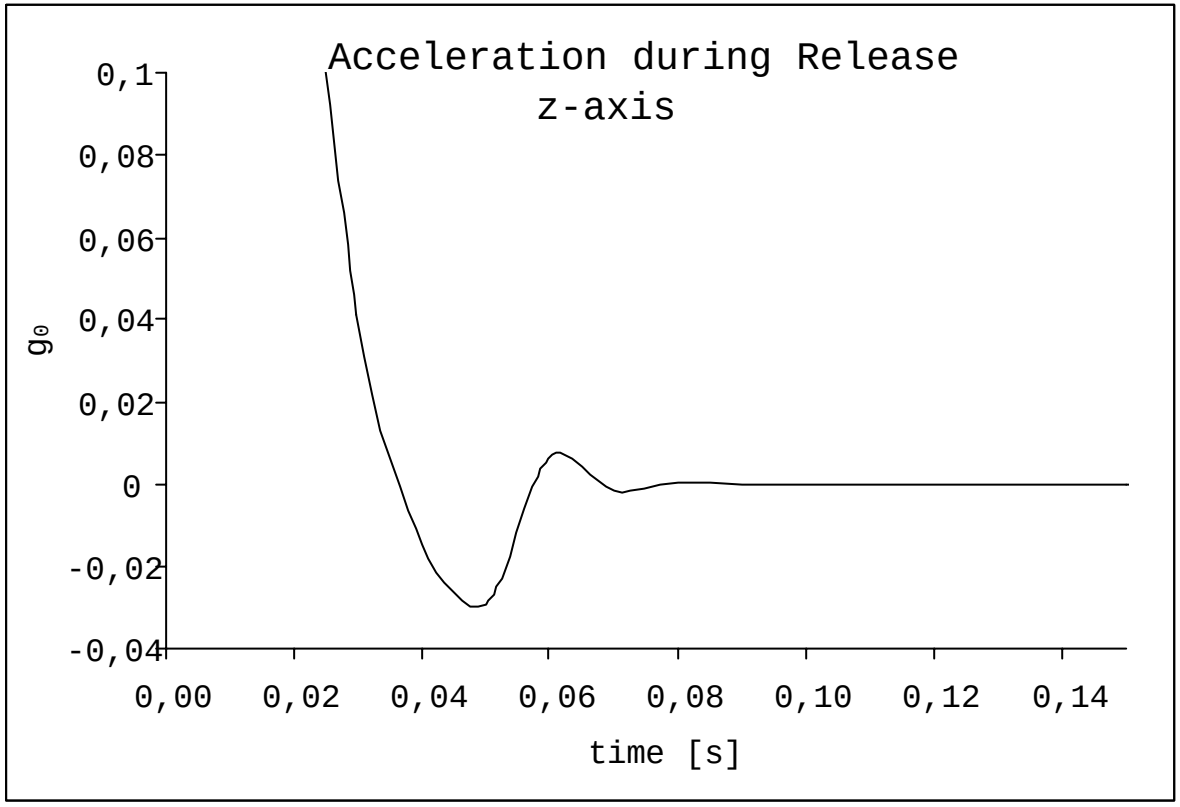


Figure 10-1: Acceleration level at time of release (ZARM)

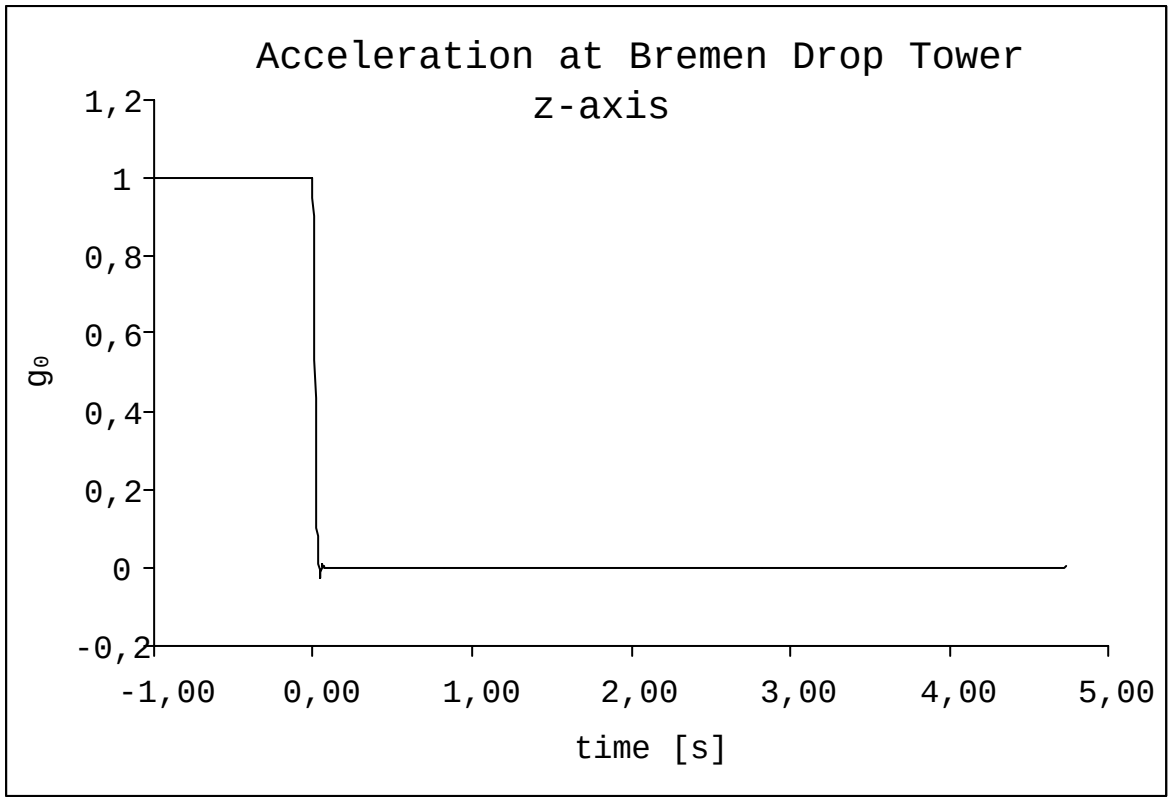


Figure 10-2: Acceleration level through drop event (ZARM)

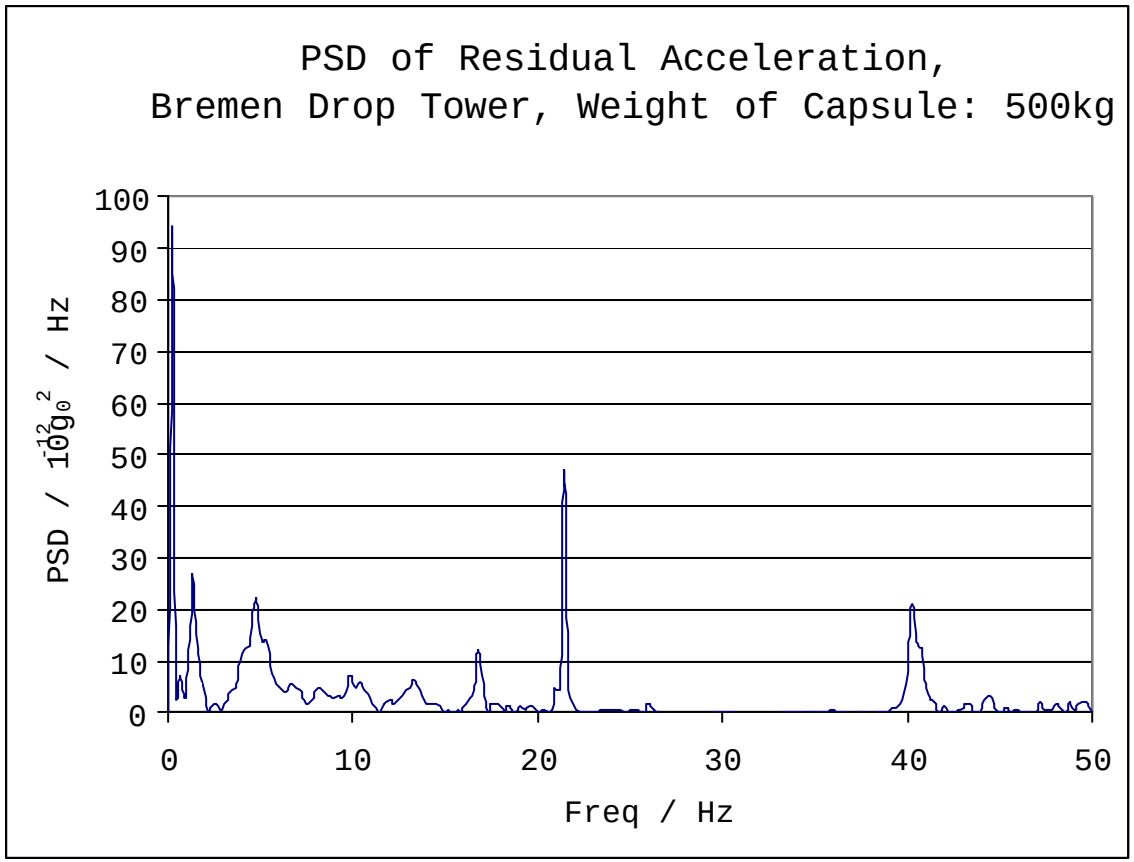


**Figure 10-3: Power Spectral Density plot during drop (ZARM)
(note: release disturbances not included)**

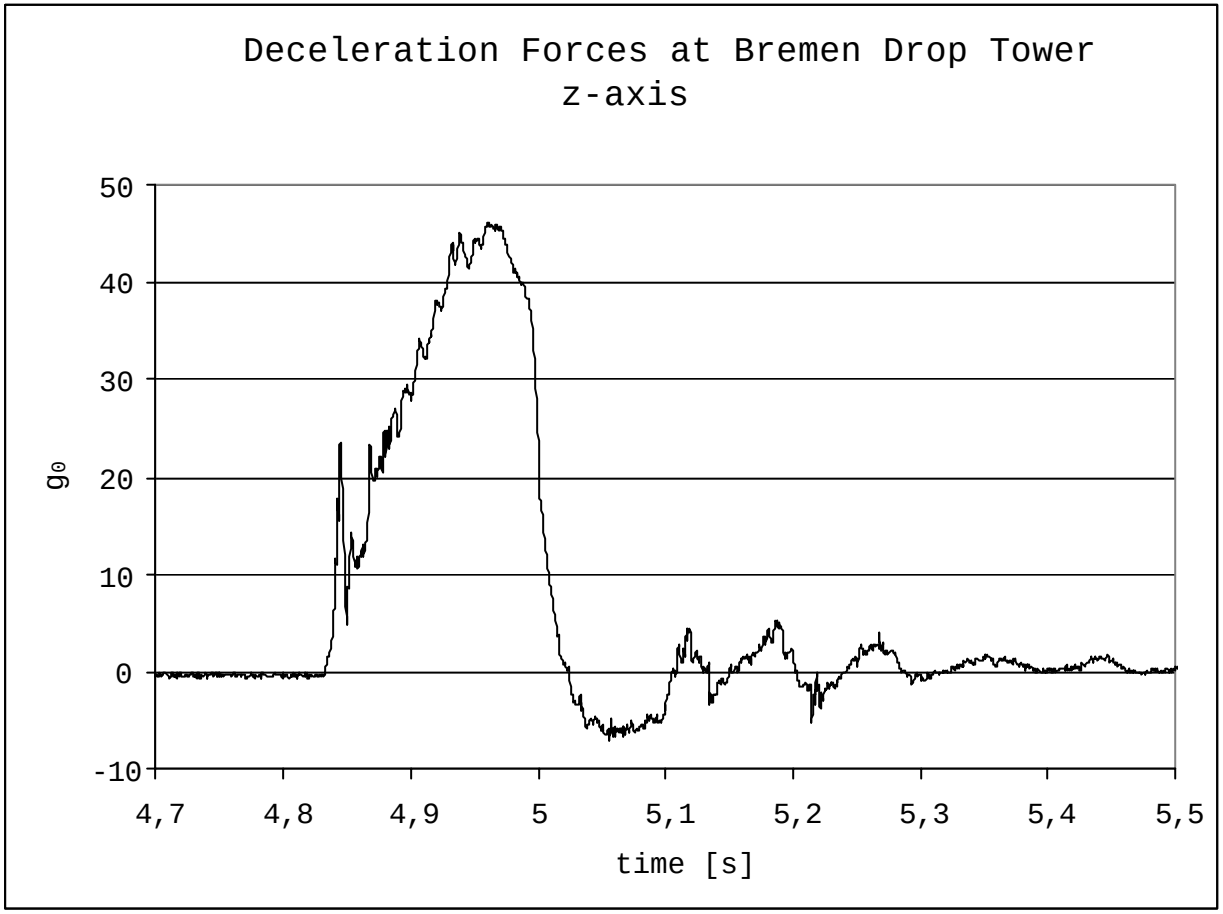


Figure 10-4: Deceleration at capture (ZARM)