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# Attempting to Promote Educational Utilization in MGLAB

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**Abstract**

The Micro-Gravity Laboratory of Japan has been providing high-quality 4.5 s microgravity environment for many researchers. In addition, we are attempting to provide microgravity environment /drop experiments for the younger generation who will produce scientific results in the future. This paper describes the facility and several examples of educational experiments.

## 1. Introduction

The construction of the microgravity drop experiment facility of the Micro-Gravity Laboratory of Japan (MGLAB) was completed in 1995. This facility provides a high-quality a4.5 s microgravity environment for researchers. We have conducted more than 6,000 drop experiments until now.

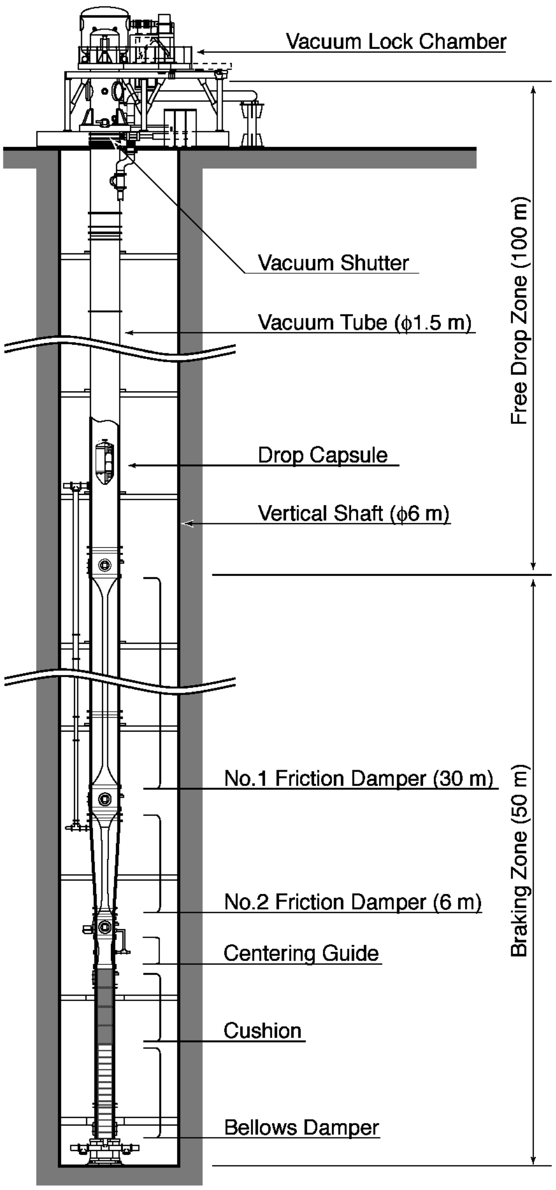


**Fig. 1** Outline of Facility

## 2. Outline of MGLAB's Facility

**Figure 1** shows the outline of the MGLAB's facility. The vacuum tube is set up below the ground and its length is approximately 150 m; further, it consists of 2 zones. The first zone is a free drop zone, which provides the 4.5 s microgravity environment; its length is approximately 100 m. The

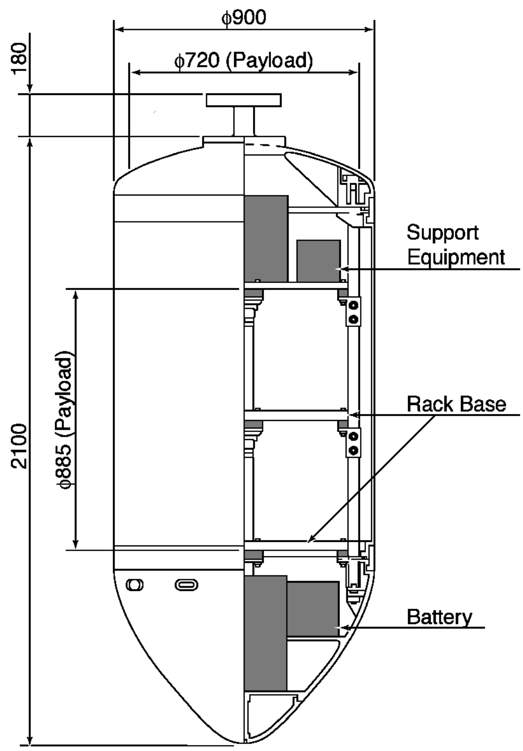


**Fig. 2** Drop Capsule

second zone is a braking zone to stop the drop capsule; its length is approximately 50 m. During the drop experiment, the vacuum tube is evacuated to omit the influence of air resistance against the drop capsule. In the braking zone, the friction dampers made of rubber can stop the drop capsule safely.

**Figure 2** shows the outline of the drop capsule. The lower part of the capsule holds the power supply, while the upper part holds the experiment support equipment. The center of the capsule consists of a cylindrical payload area that accommodates the experimental equipment of the researchers. **Table 1** shows the main specifications of the facility and the drop capsule.

**Figure 3** shows the outline of the drop experiment process. It takes approximately 70 min to carry out a drop experiment, which includes approximately 30 min of preparation time. In these 30 min, the researchers can observe the conditions of the experiment equipment and remotely control it.

**Table 1** Specifications of the Drop Facilities

Drop Experiment Equipment

| | |
|---|---|
| Drop method | Free drop in vacuum |
| Braking method | Friction damper<br>Bellows damper |
| Vertical shaft | 150 m<br>Free drop zone = 100 m<br>Braking zone = 50 m |
| Accuracy of vacuum | 4 Pa |
| Duration of μG | 4.5 s |
| Accuracy of μG | $10^{-5}$ G level |
| Braking deceleration | Target 10 G or less |

Drop Capsule

| | |
|---|---|
| Number of capsules | 2 |
| Material | Aluminum alloy |
| Outer dimensions | ϕ900, H2280 |
| Payload area | ϕ720, H885 |
| Payload weight | 400 kgf (max) |
| Total weight | 1000 kgf (max) |
| Balance | 0.5 kgf-m (max) |
| Power supply | AC 100 V 12 A<br>DC 24 V 40 A |

## 3. Outline for Promoting Educational Utilization

We believe that it is important for students to conduct drop experiments or experience the

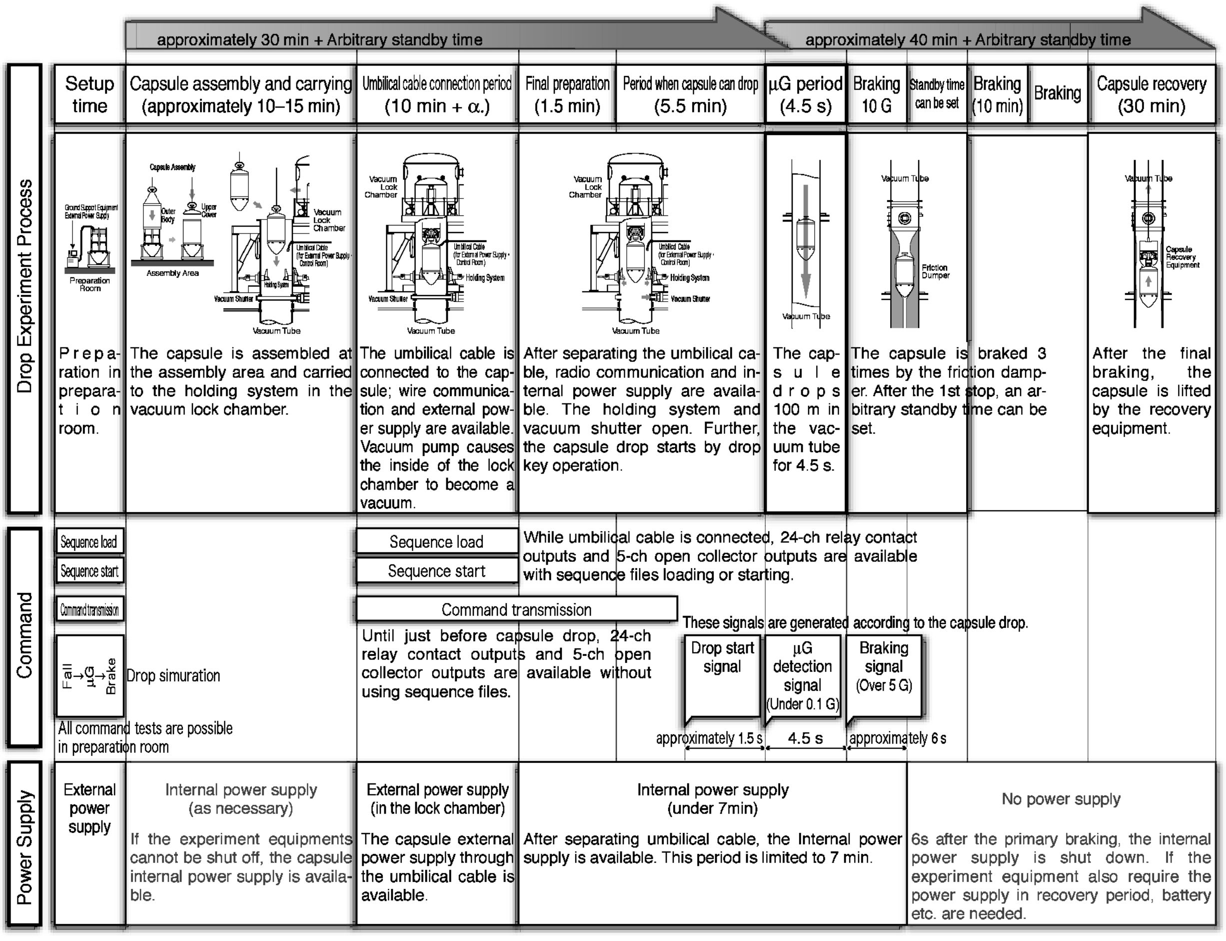


**Fig. 3** Drop Experiment Process

phenomena in a microgravity environment. Further, we believe that such promotional exercises are indispensable for producing future researches. Therefore, we are attempting to provide the opportunities for utilizing our facility for educational purpose. The concrete policy is as follows.

**a) Low price fee configuration for educational purpose**

We provide an “Educational Program” as one of our new utilization forms. In this program, the price of 1 drop experiment is 1/9 that of the regular price, since this program targets students.

**b) Providing the microgravity drop experiments for educational events**

We provide opportunities for high and junior high school students to experience the microgravity drop experiments. This facility was provided at the “Science Camp” held by Japan Science Foundation and the “Micro-Gravity Seminar” held by Gifu Prefecture, Toki City, MGLAB etc. In addition, we help the students in preparing the experimental equipments and provide them with teaching materials for these events.

## 4. Examples of the Experiments Conducted at “Science Camp”

During the science camp, 10 high school students performed experiments using two themes, which had been prepared by us. We prepared approximately 90% of the experiment equipments, while the students prepared remaining 10%.

At first, they observed the phenomena in a normal gravity environment, and they speculated how the phenomena would change in a microgravity environment. Subsequently, they carried out the drop experiments. After the experiments, they compared the results with their predictions and discussed them.

Examples of the experiments conducted at the “Spring Science Camp 2006” are as follows.

**a) Flow of air surrounding a hot wire**

The students attempted to observe the flow of air surrounding a hot wire by using the schlieren system. **Figure 4** shows the schlieren system for the drop experiment. This system shows us the density gradients in the “Test Area”. Further, the images of the density gradient were recorded by a hi-speed camera. The students prepared an electric hot wire and a circuit to control its output.

The students predicted that the upward flow would disappear in the microgravity environment. However, they could not predict the distribution of the density gradients.

**Figure 5** shows the schlieren images in normal and microgravity environments. Figure 5-A shows the upward flow due to natural convection. On the other hand, figure 5-B shows that the upward flow disappears. The density gradients are distributed isotropically and they also became sparser.

Thus, we were able to show the qualitative difference between both the environments using the

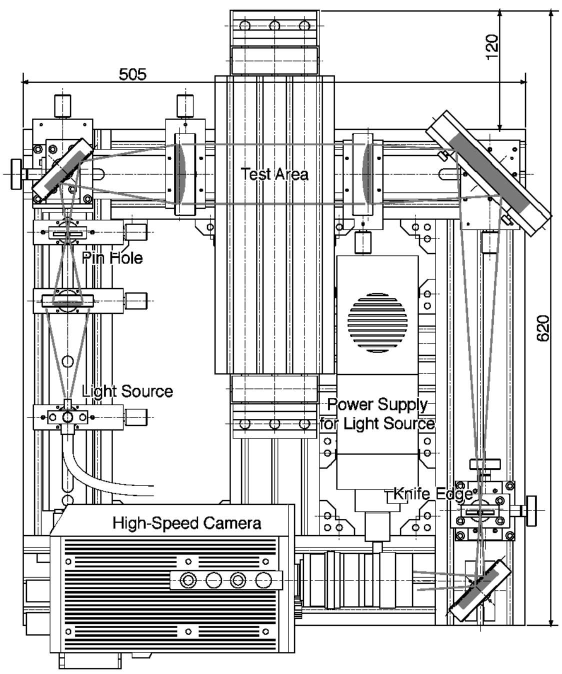


**Fig. 4** Schlieren System for Drop Experiment

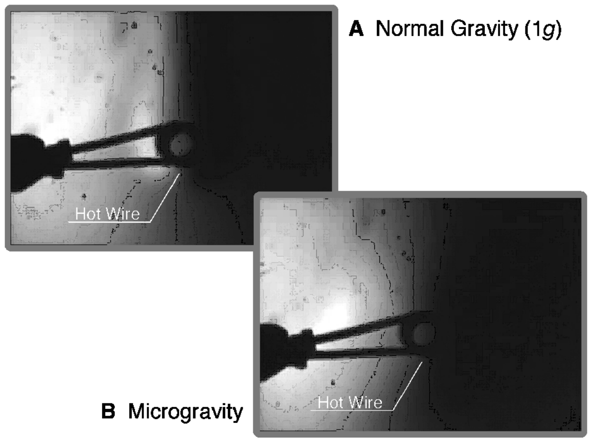


**Fig. 5** Schlieren Photograph of Hot Wire

schlieren system.

**b) Motion of a simple pendulum**

The students attempted to observe the motion of a simple pendulum. The weight is suspended by a thin stainless steel rod, and the air cylinder starts moving it from its lowest position. The students wired the lines of the control signals and the air circuit, and they observed the motion with a high-speed camera.

**Figure 6** shows the motion of the simple pendulum in normal and microgravity environments. Figure 6-A shows the motion of a simple oscillation. The students calculated the initial velocity of the weight shown in this image, and they calculated the number of degrees through which the weight would rotate in the microgravity environment.

Figure 6-B shows the circular motion at almost the same velocity. They compared the actual rotation angle with the calculated value. Then, they studied the factors that caused the error between both values.

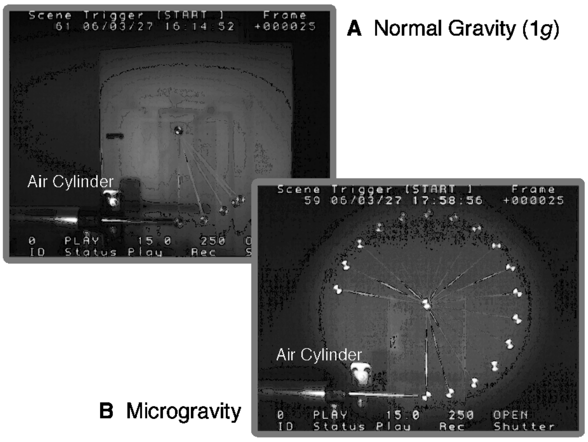


**Fig. 6** High-Speed Photograph of Pendulum Motion (Time interval : 40 ms)

## 5. Examples of experiments conducted for "Micro-Gravity Seminar"

We chose two drop experiment themes from the proposals, which are submitted by junior high school students in Toki city every year. We provide these students with opportunities to conduct the drop experiments, and thereby support their endeavor. Examples of the experiments for the "Micro-Gravity Seminar" conducted from 2004 to 2006 are given as follows.

**a) Drainage of water from a PET bottle**

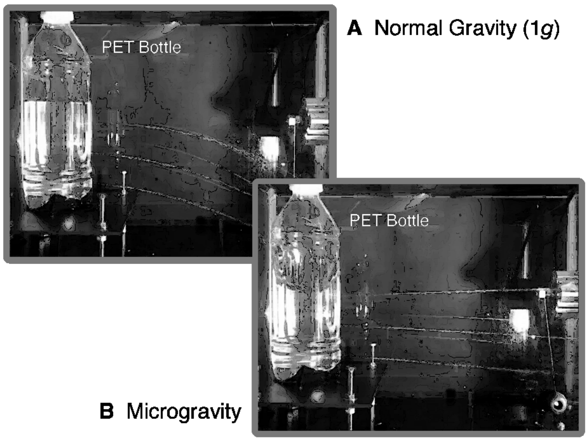


**Fig. 7** Drainage of water from a PET Bottle

The students attempted to observe the water drained from a PET bottle. There are 3 holes at the sides of the PET bottle to drain the water. At first, the 3 holes are plugged, and the pressure inside the PET bottle is increased. Immediately before the capsule drop starts, the plugs are pulled out by the air cylinder, which is remotely controlled.

**Figure 7** shows the results in normal and microgravity environments. In figure 7-A, it can be seen that the water from the PET bottle describes a parabola, while in figure 7-B, the water drains out in a straight line. In addition, the water surface in the PET bottle was considerably transformed to the shape of a bowl due to the influence of the wettability.

**b) Motion of balls**

The students attempted to observe the motion of bouncing balls. At first, the balls are held in the upper part of the test box. Immediately before the capsule drop starts, the balls are released by the air

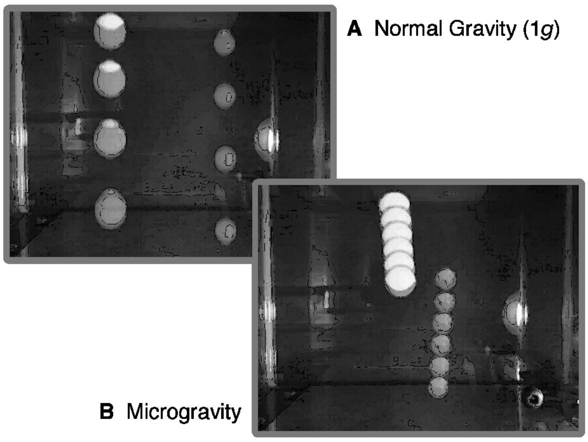


**Fig. 8** Motion of Balls (Time interval : 33 ms)

cylinder, which is remotely controlled.

The students predicted two types of results. The first one was that the balls would stop in the microgravity environment, and the second one was that the balls would move faster in the microgravity environment.

**Figure 8** shows the results in normal and microgravity environments. In figure 8-A, it can be seen that the balls accelerate gradually due to the influence of gravity, while in figure 8-B, the balls move at almost the same velocity.

The students could find that the balls maintained their velocity when they entered the microgravity environment.

**c) Pigment discharged from a tube**

The students attempted to observe the influence of microgravity environment on a pigment discharged from a tube. Immediately after entering the microgravity environment, the air cylinder, which is remotely controlled, is pushed down the tube; this discharges the pigment.

**Figure 9** shows the results in normal and microgravity environments. In figure 9-A, it can be seen that the discharged pigment drops below immediately, while in figure 9-B, the discharged pigment maintains a straight-line shape. In addition, transversal waves are slowly transmitted in the straight-line-shaped pigment.

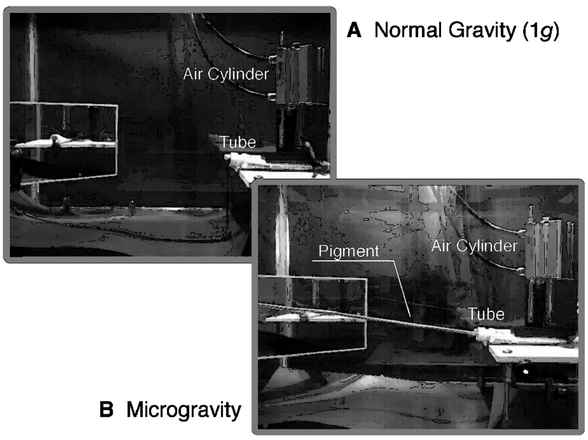


**Fig. 9** Pigment Discharged from a Tube

**d) Motion of a metronome**

The students attempted to observe the motion of a mechanical wind-up metronome, and they predicted that the metronome would work in the microgarvity environment.

**Figure 10** shows the results in normal and microgravity environments. In figure 10-A, it can be observed that the rod swings periodically, while in figure 10-B, the rod remains stationary at the turnaround point.

After the drop experiment, the students examined the metronome to find the reason why the rod stopped swinging. They found that the metronome swung not only due to the effect of the spring but also due to the effect of the internal weight.

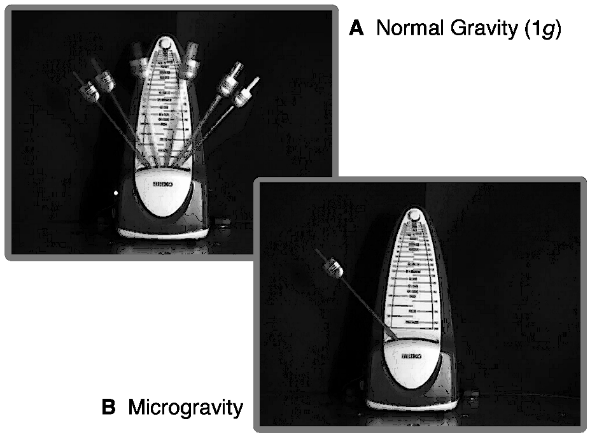


**Fig. 10** Motion of a Metronome
(Time interval : 200ms)

**e) Boiling of water**

The students attempted to observe the boiling of water in a beaker. A pipe heater is set up in the beaker as a heat source. The capsule was dropped, after the boiling started.

**Figure 11** shows the results in normal and microgravity environments. In figure 11-A, it can be observed that bubbles are actively generated from the upper side of the heater, while in figure 11-B, bubbles are actively generated from not only the upper side but also from the lower side of the heater.

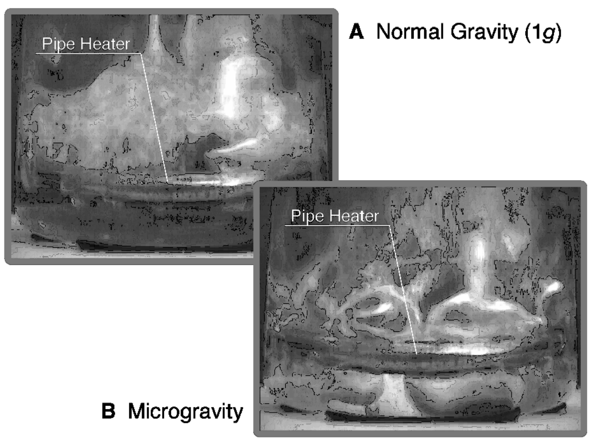


**Fig. 11** Boiling of Water

In addition, the bubbles are larger than those generated under normal gravity.

**f) Slope and a car**

The students attempted to observe the motion of a radio-controlled car on a slope. The angle of the slope can be changed. Immediately after entering the microgravity environment, the car was controlled and it began to move. Experiments for two different slope angles were conducted.

Figure 12 shows the results of the first experiment in normal and microgravity environments. In this experiment, the slope angle is 15°. In figure 12-A, it can be observed that the car can climb this slope, while in figure 12-B, immediately after entering the microgravity environment, the car moves away from the slope.

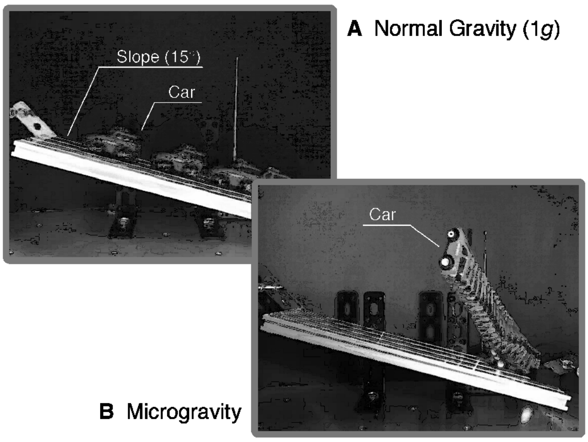


**Fig. 12** Slope (15°) and a Car
(Time interval : 200 ms)

Therefore, the students passed a thin thread through the car to prevent it from detaching from the slope. In addition, they increased the slope angle.

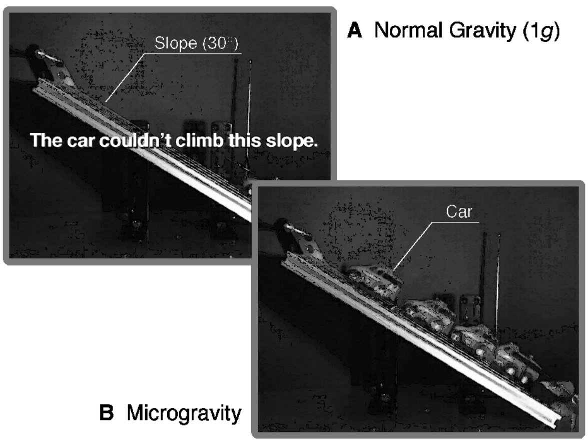


**Fig. 13** Slope (30°) and a Car
(Time interval : 200 ms)

Figure 13 shows the results of the second experiment in normal and microgravity environments. In this experiment, the slope angle is 30°. In figure 13-A, it can be observed that the car can not climb this slope in the normal gravity environment. On the other hand, in figure 13-B, it can be seen that the car can move and accelerate easily on this slope.

In the second experiment, the students had predicted that the car would not be able to climb such a steep slope. However, they were able to find that the slope angle was insignificant in the microgravity environment.

**6. Conclusion**

We have conducted the experiments mentioned above and have obtained favorable comments and results. We hope that more students take greater interest in science and technology because of our attempts.

If you wish to know more about our other activities/experiments and more details about the MGLAB facility, please refer to the following link:

http://www.mglab.co.jp/

**References**

1) MGLAB, "Micro-Gravity Drop Experiment Facility User's Guide", 2006.

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