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## 🌐 Assembling simple and universal adjustable multiheight smartphone stand for lab microscopes

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**We use this protocol and it's working**

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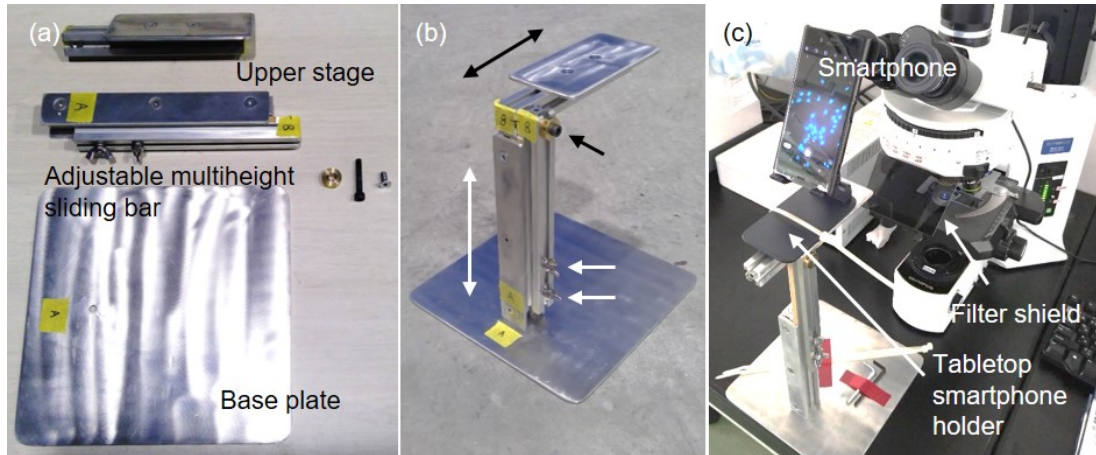
**The Center for Industry  
Collaboration Project (project  
name: Application of  
Microfabrication Techniques  
for Cell Culture) at the  
National Institute of  
Technology, Kumamoto  
College.**

## Abstract

Cameras in mobile devices such as smartphones and tablets have recently been used to capture or display images from microscopes in various fields. The advantages of using these cameras are their low cost, simple operation, and the possibility of capturing high-resolution images and movies. Many commercial products can be easily attached and aligned, from smartphones to microscopes (e.g., SWIFT SPA-E28 Smartphone Adapter, LabCam and LabCam Ultra). However, suitable accessories are sometimes required depending on the type of microscope or smartphone used. Therefore, we designed an adjustable multiheight smartphone stand. The height and position of the upper stage of this stand can be flexibly adjusted, making it suitable for various smartphone and microscope models with a single stand. It is robust, highly stable, and routinely used in laboratories, schools, and factories. We used a commercial tabletop smartphone holder on the upper stage to reduce assembly time and cost. This stand enable the capturing or recording of the object on your smartphone seen through the microscope without additional new equipment. Specifically, this stand may be useful in situations in which many people use their smartphones to capture images from a microscope, such as in laboratories, student experiments, and outreach activities.

## Guidelines

The widths and positions of the cameras were different for each smartphone. Moreover, the position of the eyepieces varies depending on the type of microscope used. Therefore, we designed an adjustable multiheight smartphone stand that could capture and display images through the eyepiece of a microscope with a smartphone. This stand consisted of three parts: an upper stage, a sliding bar, and a base plate (Figure (a)). The length of the sliding bar was adjusted using two wing bolts. In addition, the position of the upper stage can be adjusted using another bolt (Figure (b)). We used a commercial tabletop smartphone holder, which is an adjustable multiangle type, on the upper stage of the stand. The position of the upper stage was adjusted by using a fluorescence microscope equipped with a filter shield (Figure (c)).



## Materials

### Upper stage

- Aluminum plate (70 mm × 40 mm × 5 mm) x1
- 20 mm × 20 mm T-slot aluminum extrusion, 115 mm (HFS5-2020-115, MISUMI Corporation, Japan) x1
- T-slot nut (HNTTSS5-5, MISUMI Corporation, Japan) x2
- Countersunk screws (SFB5-8, MISUMI Corporation, Japan) x2
- Bolt (CSHHNS-ST-M5-25, MISUMI Corporation, Japan) x1
- Washer (WSX-SUS-M5X18-3, MISUMI Corporation, Japan) x1
- Tabletop smartphone holder (STD04-BK, Owltech Co.,Ltd., Japan) x1

### Adjustable multiheight sliding bar

- 20 mm × 20 mm T-slot aluminum extrusion, 150 mm (HFS5-2020-150-AV15-BV35-CV140, MISUMI Corporation, Japan) x1
- 20 mm × 20 mm T-slot aluminum extrusion, 180 mm (HFS5-2020-180, MISUMI Corporation, Japan) x1
- Aluminum plate for guide plate (25 mm x 180 mm x 5 mm) x2
- Countersunk screws (SFB5-8, MISUMI Corporation, Japan) x6
- T-slot nut (HNTTSS5-5, MISUMI Corporation, Japan) x8
- Wing bolt (HANWGRR-SUS-M5-25, MISUMI Corporation, Japan) x2
- Threshold slippery tape (Pro Suberri, No Paper 0.8 inches x 65.6 ft Roll, Kawaguchi Giken, Japan) x1
- T-slot aluminum extrusion end cap (HFCB5-2020-Y, MISUMI Corporation, Japan) x1

### Base plate

- Aluminum plate for base plate (200 mm × 200 mm × 5 mm) x1
- Countersunk screws (SFB5-8, MISUMI Corporation, Japan) x1

### Tools for assembling

- 4-mm hexagonal wrench
- 3-mm hexagonal wrench

### Tools for metal processing

We used processing machines to fabricate aluminum parts as follows:

- Tabletop drilling machine (B13SH-100V, Koki Holdings Co., Ltd., Japan)
- Contour machine (L-400, luxco Co.,LTD, Japan).

If you cannot access these processing machines, you available these tools as follows:

- Handy saw (e.g., K-402, KANZAWA WORKS CO.,LTD., Japan)
- Impact driver (e.g., DF484DRGX, Makita Corporation, Japan)

Please use a contour machine or an impact driver that can attached maximum 13 mm drill.

### Design Files

We provided PDF and STEP files of this smartphone stand for others to use freely or modify to fit their educational or research needs.



Adjustable multiheight smartphone stand (PDF file)

[https://drive.google.com/drive/folders/1Xt44FeB-D2R\\_zW\\_0F0ww5Ej5613B\\_TFd?usp=sharing](https://drive.google.com/drive/folders/1Xt44FeB-D2R_zW_0F0ww5Ej5613B_TFd?usp=sharing)

Adjustable multiheight smartphone stand (STEP file)

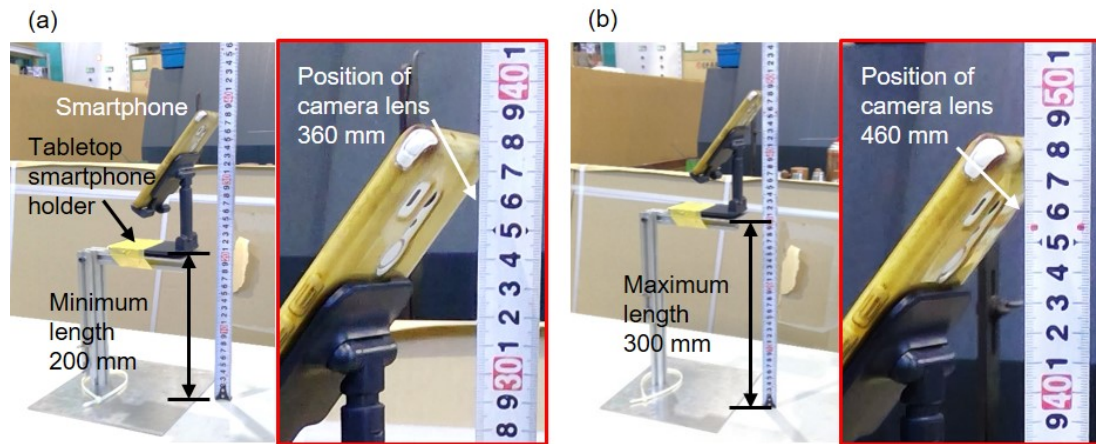
<https://drive.google.com/drive/folders/1y7xmUY8Q0FshwqcGpg1qPCZ5rUrERuq8?usp=sharing>

## Safety warnings

- ❗ We built a stand in a metal factory at the National Institute of Technology, Kumamoto College, Japan. Sanding burrs and sharp edges of cut surfaces are highly recommended to create smoother and safer edges on stands. Although readily available tools such as a handheld saw, band saw, handheld drill, or drill press could have been used to fabricate this stand, handling these tools is difficult for those who are not accustomed to it. Therefore, for safety purposes, we recommend using an external processing service.

## Before start

We used robust, lightweight, and inexpensive aluminum. We recommend using aluminum for these three parts because the upper stage becomes unstable when the sliding bar reaches its maximum length. If the user is built according to this design, it can fit a microscope with a height of approximately 360–460 mm from the eyepiece to the stage (Figure (a) and (b)). The upper stage was designed for use with a tabletop smartphone holder that weighed approximately 180 g and had dimensions of approximately 70 mm × 100 mm (width × height).



Although readily available tools such as a handheld saw, band saw, handheld drill, or drill press could have been used to fabricate this stand, handling these tools is difficult for those who are not accustomed to it. Therefore, for safety purposes, we recommend using an external processing service. For example, Meviy is a metal processing service in Japan that uses only 3D data. We provided PDF and STEP files of this smartphone stand for others to use freely or modify to fit their educational or research needs.

Adjustable multiheight smartphone stand (PDF file)

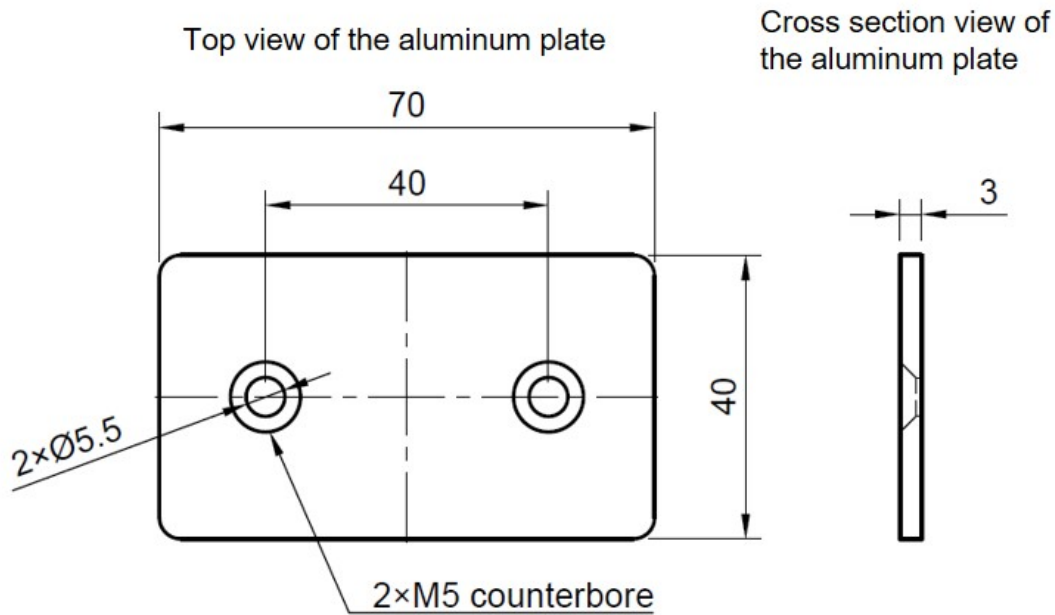
[https://drive.google.com/drive/folders/1Xt44FeB-D2R\\_zW\\_0F0ww5Ej5613B\\_TFd?usp=sharing](https://drive.google.com/drive/folders/1Xt44FeB-D2R_zW_0F0ww5Ej5613B_TFd?usp=sharing)

Adjustable multiheight smartphone stand (STEP file)

<https://drive.google.com/drive/folders/1y7xmUY8Q0FshwqcGpg1qPCZ5rUrERuq8?usp=sharing>

## Fabricating the upper stage

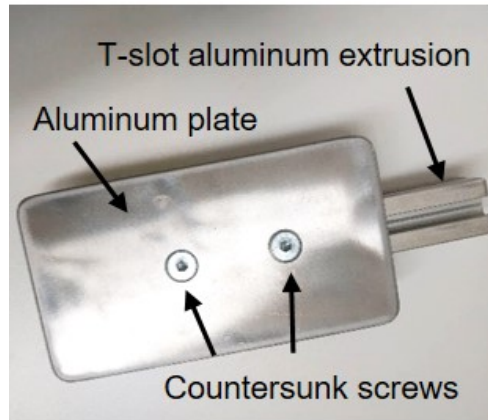
- 1 An upper stage is built using an aluminum plate (70 mm × 40 mm × 3 mm), 20 mm × 20 mm T-slot aluminum extrusion (length is 115 mm), two T-slot nuts, and two countersunk screws. As in the figure below two holes are drilled into the aluminum plate using a drill.



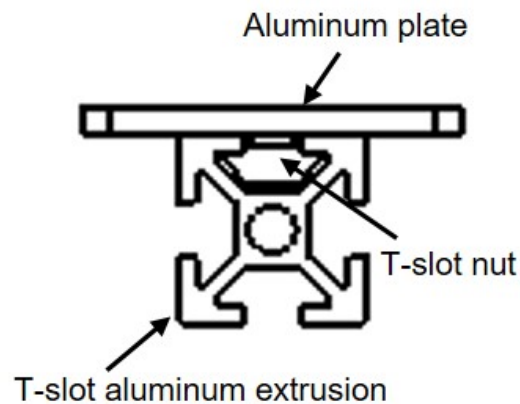
- 2 As in the figure below the aluminum plate is affixed to the 20 mm × 20 mm T-slot aluminum extrusion using two T-slot nuts and two countersunk screws.



Top view of the upper stage

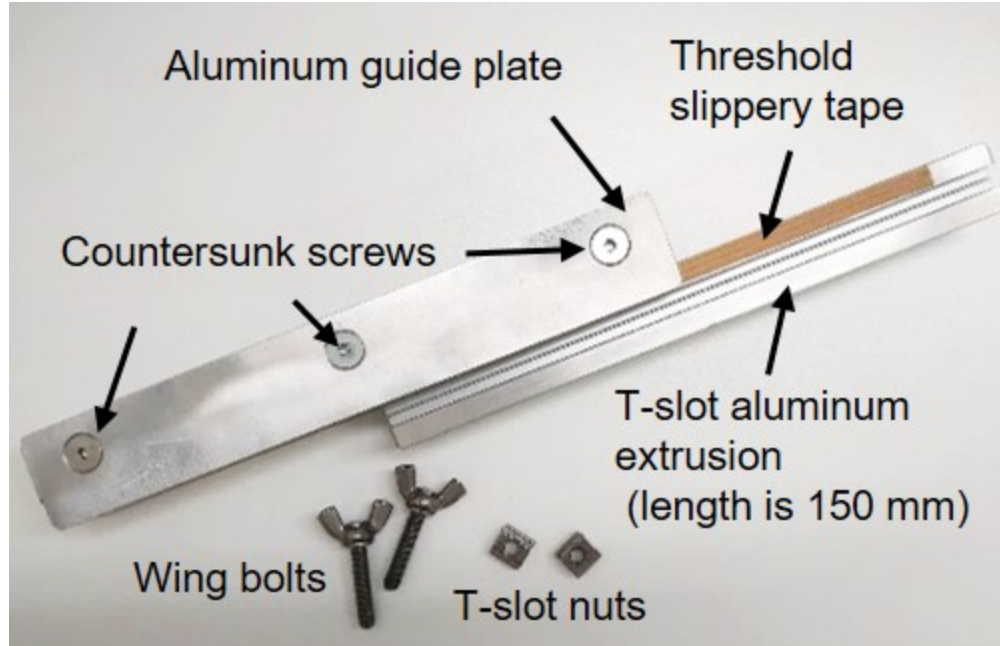


Cross section view of the upper stage



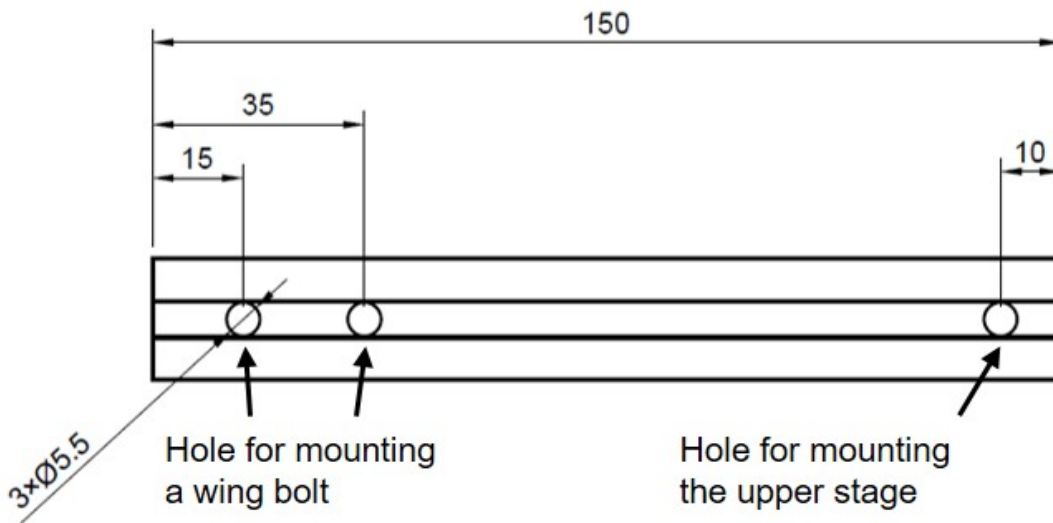
### Fabricating the adjustable multiheight sliding bar

- 3 An adjustable multiheight sliding bar is built using two 20 mm × 20 mm T-slot aluminum extrusions (length is 150 mm and 180 mm), six countersunk screws, two aluminum guide plates, eight T-slot nuts, and two wing bolts.

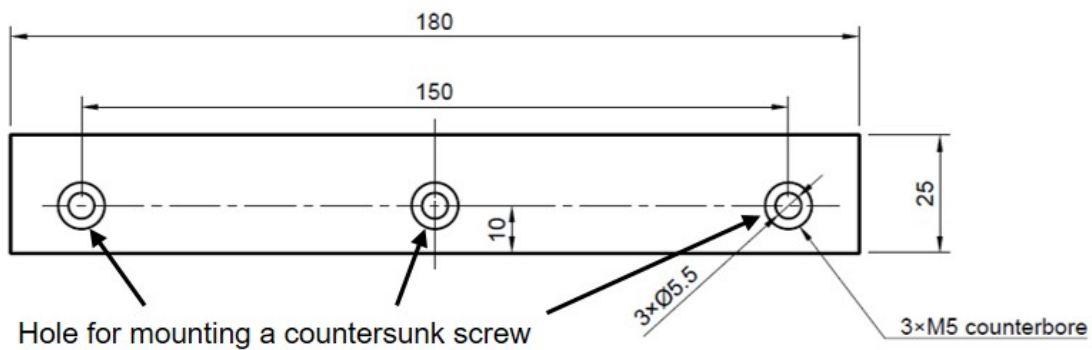




- 4 As in the figure below three holes are drilled into the 20 mm × 20 mm T-slot aluminum extrusions (length is 150 mm) using a drill.



- 5 As in the figure below three holes are drilled into the two aluminum guide plates using a drill.

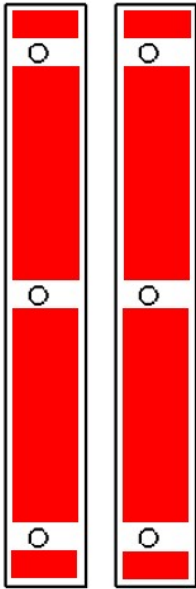


- 6 As in the figure below stick a threshold slippery tape onto 20 mm x 20 mm T-slot aluminum extrusions and aluminum guide plates to enable smooth movement of the T-slot aluminum extrusions.

(a)

Position of threshold slippery tape  
(Red squares in the below figure)

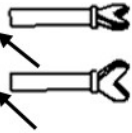
Aluminum guide  
plates (inside)



T-slot aluminum  
extrusion  
(length is 150 mm)

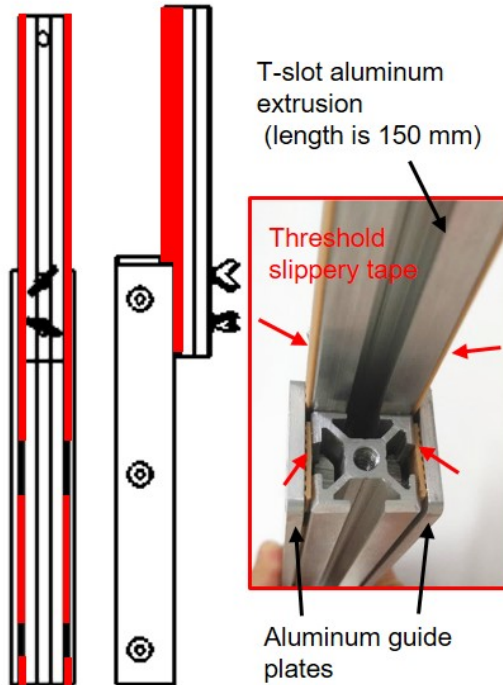


Holes for mounting  
wing bolts



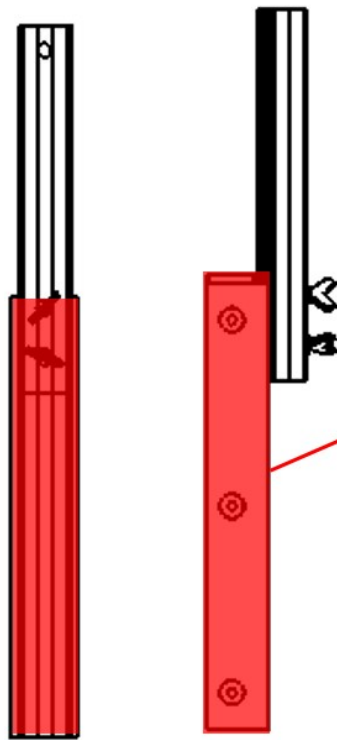
(b)

Overall view of the adjustable multiheight  
sliding bar

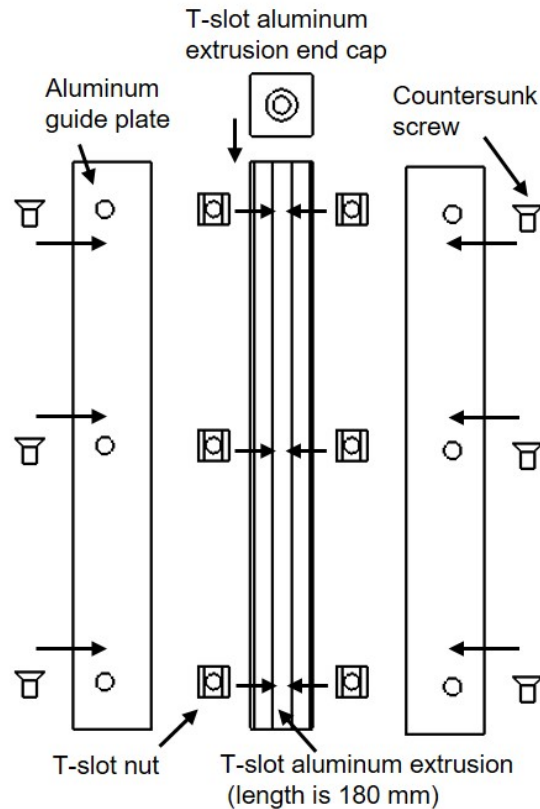


- 7 As in the figure below slide and insert six T-slot nuts into T-slot aluminum extrusion (length is 180 mm). Align the aluminum guide plate with three screw holes of T-slot aluminum extrusion and T-slot nuts. Two aluminum guide plate is affixed to the T-slot aluminum extrusion using six countersunk screws and six T-slot nuts.

Overall view of the adjustable multiheight sliding bar

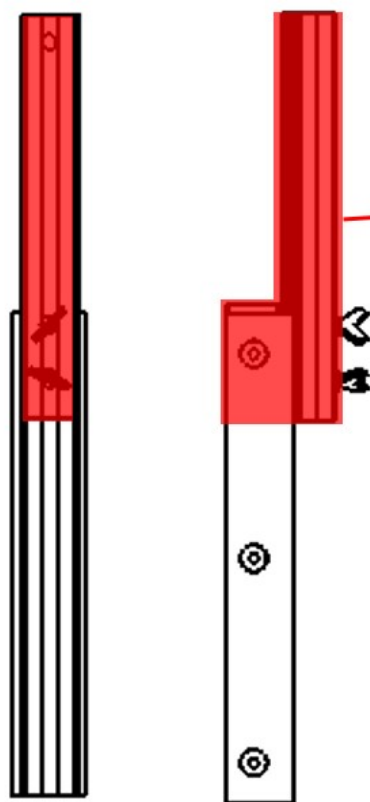


Exploded view of the bottom part of the adjustable multiheight sliding bar

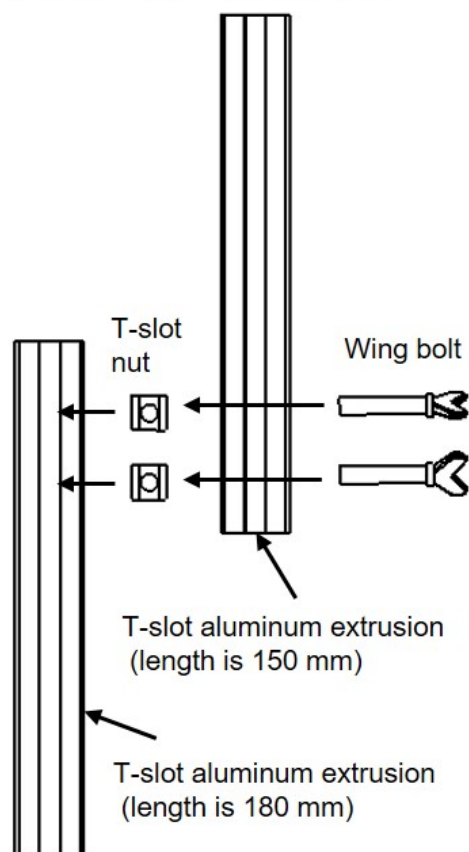


- 8 As in the figure below slide and insert two T-slot nuts into T-slot aluminum extrusion (length is 180 mm). Two wing bolts are tightened into a T-slot nut. The T-slot nut moves flexibly in the rail of the T-slot aluminum extrusion (length is 180 mm); therefore, the T-slot aluminum extrusion can be fixed at any position. When the two wing bolts were loosened, the sliding bar moved upward and downward.

Overall view of the adjustable multiheight sliding bar

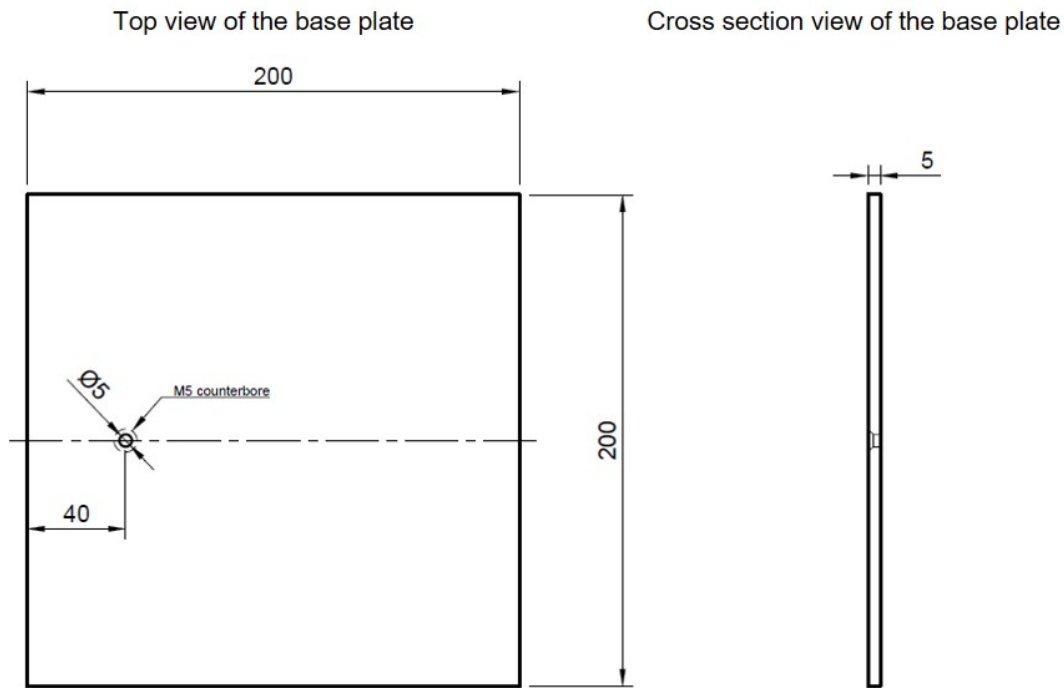


Exploded view of the upper part of the adjustable multiheight sliding bar

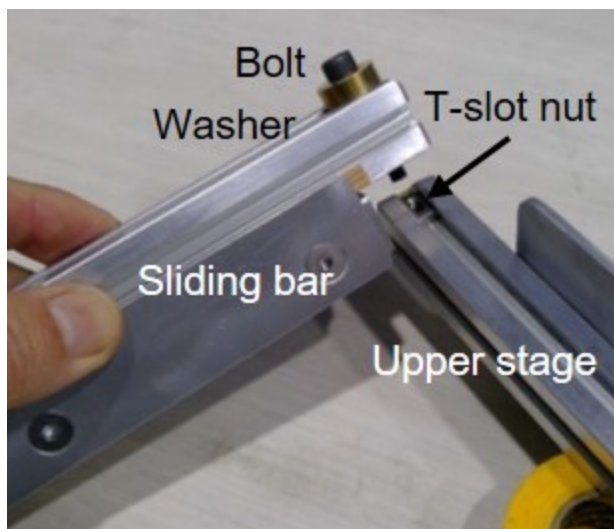


## Fabricating the base plate and Building the adjustable multiheight smartphone stand

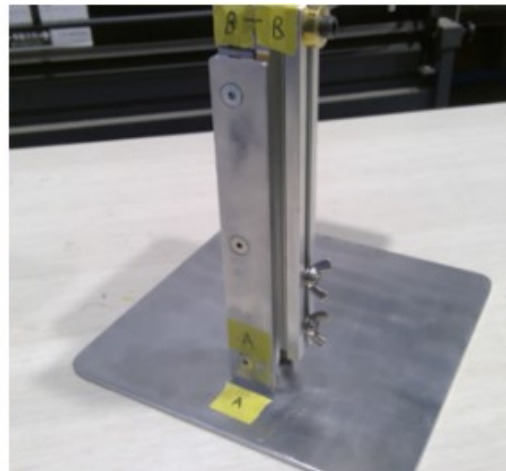
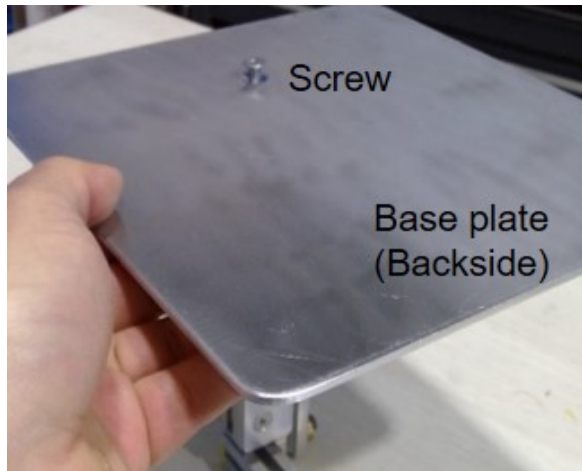
- 9 As in the figure below a hole is drilled into the aluminum base plate using drill.



- 10 The upper stage is maintained in a horizontal position, and the bolt is tightened into a T-slot nut using a 4-mm hexagonal wrench. The T-slot nut moves flexibly in the rail of the T-slot aluminum extrusion; therefore, the upper stage can be fixed at any position. Ensure that the washer has been inserted.



- 11 The sliding bar is fixed from the back side of the base plate with a screw using a 3-mm hexagonal wrench.



## Operation instructions

- 12 A tabletop smartphone holder was fixed to the upper stage using cable ties or tape. The stand was subsequently placed on a stable surface. The mounting position of the upper stage was determined according to the height and shape of the microscope, and fixed with a hexagonal wrench. The length of the sliding bar is adjusted using two wing bolts. After adjusting the height, the angle of the commercially available smartphone stand was adjusted along with the distance between the smartphone camera and eyepiece of the microscope.

## Demonstration of the fabricated stand using various situations

- 13 Images were captured and displayed using different microscopes, smartphones, and situations (Figure (a) and (b)). We used a commercial tabletop smartphone holder, which is an adjustable multiangle type, on the upper stage of the stand. We observed fluorescent dye-stained NIH/3T3 cells using a fluorescence microscope (BX51, Olympus Corporation, Japan) and an Android smartphone (Xperia 10 II, Sony Corporation, Japan) at the Biological Laboratory of Akita University (Figure (a)). Cultured NIH/3T3 cells on a cover glass were stained with fluorescein diacetate). In addition, we used a stereomicroscope (S6D, Leica Microsystems, Germany) and an Android smartphone (arrows F-02L, FCNT Ltd., Japan) to observe the metal ruler in the metal factory at the National Institute of Technology, Kumamoto College, Japan (Figure (b)).

