APPENDIX. SUPPORTING MATERIAL

Here, detailed instructions are provided for

a) Detailed specifications of essential pieces of equipment
b) Physical positioning of the equipment
c) Software configurations of the Windows 10 operating system, OBS Studio and Zoom software.

A. Equipment List and Specifications

The suggested specifications of the major essential items are listed in Table 1.

Table 1
Suggested specifications of major pieces of equipment.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Suggested Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Webcam</td>
<td>- 1080p and 720p streaming at 30 frames per second or better</td>
</tr>
<tr>
<td></td>
<td>- Diagonal field of view (FOV) of at least 78° (90° preferred)</td>
</tr>
<tr>
<td>LED Monitors</td>
<td>- Two sets of 23-inch monitors with 1080p display resolution or better</td>
</tr>
<tr>
<td>Laptop</td>
<td>- Intel i7 or Ryzen 7 CPU processors @ 2.80 GHz or faster</td>
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<tr>
<td></td>
<td>- 16 GB RAM or better</td>
</tr>
<tr>
<td></td>
<td>- 13-inch LED screen (touchscreen optional)</td>
</tr>
<tr>
<td></td>
<td>- Intel HD 620 graphics or better (separate graphics card preferred)</td>
</tr>
<tr>
<td></td>
<td>- At least 2 in-built video display output ports (mini or full-sized HDMI or DP ports).</td>
</tr>
<tr>
<td></td>
<td>USB type C output ports may serve in-lieu of display ports, but</td>
</tr>
<tr>
<td></td>
<td>they will require additional video adaptors.</td>
</tr>
<tr>
<td>Green Screen</td>
<td>- Wall-mountable or portable</td>
</tr>
<tr>
<td></td>
<td>- Minimum dimension of 2m×1m (roughly 6×3 feet)</td>
</tr>
<tr>
<td>Microphone (Optional)</td>
<td>- Basic wired or wireless lavalier (clip-on) microphones</td>
</tr>
<tr>
<td>Additional Lighting</td>
<td>- Desktop or stand lamps that improve facial illumination, if room lighting is</td>
</tr>
<tr>
<td>Equipment (Optional)</td>
<td>insufficient.</td>
</tr>
</tbody>
</table>

B. Physical Positioning of Equipment Pieces

The studio setup should be tailored to the individual teacher’s physical height. As such, the following descriptions of the setup are not expressed in terms of absolute length units. First, the green screen is set up on a supporting structure in the landscape orientation from roughly the height of the teacher’s hip upwards. The green screen should be large enough such that the top of the lecturer’s head does not reach the top of the screen. While standing immediately in front of the green screen, the two LED screens and a laptop are set up roughly an arm’s length away. The monitors’ height and positioning should be such that the webcam, when mounted on top of one of the LED monitors, is roughly at eye level and pointing at the approximate geometric centre of the green screen. The laptop should be placed at about waist height within a comfortable reach of the hands (Figure 1).
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Figure 1. Positioning of the laptop, LED monitors and webcam in relation to the green screen.

During the setup process, it is important to note the following:

- Ensure there is adequate access to electrical power for the entire setup and that the laptop is connected to the internet via wired LAN. Using only WiFi connection is not recommended.
- Ensure that the room is well-lit. It is recommended to have an additional light source placed near the LED screens that directs diffused light towards the lecturer’s face.
- To improve the lecture quality and the students’ learning experience, we recommend using separate lavalier (clip-on) microphones. Since the setup is not installed in a proper studio with padded walls and ceilings, the acoustic reverberation from the lecturer’s voice may be distracting if only the webcam’s microphone is used. A basic lavalier microphone is sufficient.
- As the live streaming may be operationally intensive for the laptop, you may wish to include an optional laptop air cooling pad to reduce heat stress to the laptop.

C. Installing and Configuration of the OBS Studio Software

Windows 10 Settings

- The LED monitors connected to the laptop must be set up as multiple monitors within Windows 10. It is highly recommended that each LED display is arranged according to its position relative to the laptop. Detailed instructions are provided at Microsoft’s support website.
- Detailed instructions on configuring the external microphones are provided at Microsoft’s support website.
OBS Studio Software Installation and Configuration

- Download the latest version of the open-source OBS Studio software.
- Launch the software, and an Auto-Configuration Wizard dialogue box automatically pops up. Click on "Cancel" to dismiss the dialog box.
- You will now see the following screen:

![Main Screen](image)

**Figure 2.** Main screen of the OBS Studio software.

- Click on the “Settings” button on the bottom right of the screen, as outlined and labelled as “1” in Figure 2.
- Select the “Output” tab on the left of the dialogue box (Figure 3).

![Output Dialogue Box](image)

**Figure 3.** “Output” dialogue box.
Under “Video Bitrate”, a value of 1500 kbps should be sufficient for our purposes. You may increase this value to 2000 kbps or even 2500 kbps if you wish to improve the video output quality.

Under “Recording Path”, define the folder where the recordings of the lectures will be stored.

Under “Recording Quality”, select “High Quality, Medium File Size”.

Under “Recording Format”, select “mp4”.

Leave all other options as their default values.

Click on “Apply” button on the bottom right of the dialog box.

Select the “Video” tab on the left of the dialog box (Figure 4).

Under “Base (Canvas) Resolution”, select (1920×1080) for full HD streaming at 1080p resolution. Alternatively, (1280×720) may be selected for streaming at 720p resolution. Unless high-definition 3D images or video clips are involved, 720p is generally sufficient for most academic lectures that involve text-based lecture slides containing annotations, animations, and videos.

Under FPS (i.e. Frames Per Second), select “25 PAL” or “30”. Higher FPS is required if you wish to show videos with high frame rates, but this will result in large file sizes for local lecture recordings done by OBS Studio.

Leave all other options as their default values.

Click on “Apply” button on the bottom right of the dialog box.

Then click on “OK” to dismiss the dialog box.

Click on the “+” button under “Sources” on the bottom left of the main screen, as circled and labelled as “2” in Figure 2.

Select “Video Capture Device”, then click on “OK” to dismiss all dialog boxes that pop up. You should see that the images captured by the webcam is now displayed on the main screen (as labelled with yellow font and boundary in Figure 2).
Under “Sources”, just above the circle labelled “2” in Figure 2, an item named “Video Capture Device” will appear. Left click on this item to ensure that it is selected, then right click on it.

Select “Filter” from the list that appears (it should be the second-last option on the list). A dialog box will pop up.

On the extreme bottom left of this dialog box (under “Effects Filters”), click on “+” and select “Chroma Key”. It should be the second option on the list that appears. Then click “OK” to dismiss the “Filter Name” dialogue box (but not the “Filters for ‘Video Capture Device’” dialogue box). An item named “Chroma Key” will appear under “Effects Filters”.

Stand in front of the green screen. You will notice that the green screen background is digitally removed. Ensure that you do not wear green-coloured clothing for your online lectures.

A series of slider bars will appear on the bottom right of the “Filters for ‘Video Capture Device’” dialog box (Figure 5).

Ensure that the first option “Key Color Type” is set as “Green”.

You may vary the other slider bars individually to optimise the quality of the digital background removal effect.

Then click on “Close” to close the dialogue box to return to the main screen.

Move the OBS Studio Window to the LED screen that carries the webcam.

**Project Lecture Content on Laptop Screen**

Next, the lecture content should be projected on the laptop’s screen. Any software may be used to project the content you need: lecture slides, videos, spreadsheets, emails, web browsers etc.

In particular, when using Microsoft PowerPoint slides:

Ensure the Presenter View is disabled. Go to the “Slide Show” menu and uncheck the box beside “Use Presenter View”.

Ensure that the slide show will be projected onto the laptop screen and not on one of the LED monitors. Go to the “Slide Show” menu, under “Monitor”, select “Primary Monitor”.

Launch the full-screen slide show mode on the laptop screen.

This works with all other software; whatever that is shown on the laptop screen will be displayed as the lecture content behind the lecturer during the session.
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**Compositing Webcam and Content on Laptop Screen into a Single Frame**

- Click on the “+” button under “Sources” on the bottom left of the main screen, as circled and labelled as “2” in Figure 2.
- Select “Display Capture”. It should be the fifth item on the list that appears. Click “OK” to close the first dialogue box that pops up.
- On the next dialogue box titled “Properties for ‘Display Capture’”, under “Display”, select the laptop display from the list. Then click on “OK” to dismiss the dialogue box.
- You should now be able to see the laptop screen’s content on the main screen of OBS Studio.
- Under “Sources”, just above the circle labelled as “2” in Figure 2, locate the item named “Video Capture Device” again. Left click on this item to ensure it is selected.
- Click on the button labelled “^” on the right of the “+” button in Figure 1. Ensure that the item named “Video Capture Device” is now positioned above the item named “Display Capture”.
- On the main screen, the webcam video will now appear *in front* of the laptop screen content.

**Resizing and Positioning the Content and Webcam Windows**

- The next step is to resize the windows on the main screen.
- There are now two windows on the main screen: the **webcam window** in front, and the **lecture content window** at the rear.
- Each of these two windows may be selected by directly clicking on them on the main screen (see Figure 2), or clicking on the respective item under “Sources”, just above the circle labelled “2” in the figure.
- Once selected, you will notice a red boundary on the main screen that defines each window. The window may freely be resized by modifying the red boundary or repositioned by clicking and dragging.
- **Select the laptop screen window**. Ensure that the red boundaries completely fill the entire main screen (as labelled with yellow font and boundary in Figure 2).
- **Select the webcam window**. Resize and reposition the webcam window such that you will appear with a desired size at the desired position on the main screen:
  
  - The red boundary defining the webcam window will most likely not exactly fit the main screen. When positioned properly, the window will usually extend out of the main screen (Figure 6). The parts of the window outside of the main screen will not be visible to you and the students.
  
  - Important considerations during resizing and repositioning are:
    
    a) The extent of truncation of your image on the main screen. This determines the size and extent of your image that will be visible on the screen.
    
    b) The ability for your image to access different parts of the screen. It is best to ensure that you will be able to reach and point at all parts of the lecture content on the main screen behind you without your fingers being digitally truncated.
Figure 6. Positioning and sizing the webcam video.

- Figure 7 shows the final composited image from both windows. In this figure, the chroma key parameters are non-optimal, resulting in an incomplete background removal that causes a slight greenish tinge that appears throughout the webcam window that overlays the lecture content. To reduce this effect, ensure that both the green screen and yourself are abundantly lit using sufficient room lighting and additional lighting sources. Then go to the next step.
- To adjust the chroma key parameters again, locate the item named “Video Capture Device” under “Sources” again (just above the circle labelled “2” in Figure 2). Left click on this item to ensure that it is selected, then right click on it. Then select “Filters” and left click on the “Chroma Key” item under “Effects Filters” on the left. This will bring up the parameters in Figure 5 again.

Figure 7. The composited images from both windows.
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Conducting Online Lectures using Zoom

- Launch the Zoom meeting and have the Zoom window/interface moved to the LED monitor that does not carry the webcam.
- Right click on the main screen of the OBS Studio interface. Select “Fullscreen Projector (Preview)”, then select the external LED screen that does not carry the webcam from the list. This produces a separate display that can be used by the “Share Screen” function on Zoom (as well as other streaming platforms such as Microsoft Teams).
- Press Alt+Tab repeatedly to ensure that (a) the lecture content in full-screen slide show mode is displayed on the laptop screen, (b) the OBS control screen (Figure 7) is displayed on the LED screen that carries the webcam, and (c) the composited “Fullscreen Projector (Preview)” is displayed on the LED screen that does not carry the webcam.
- On the Zoom software, launch the “Share Screen” function. Select the window named “Fullscreen Projector (Preview)”. The “You are screen-sharing” Zoom control bar will appear on the laptop screen. You may wish to drag it out and place it on the LED screen carrying the webcam, or otherwise simply leave it there, depending on your preference.
- You may now begin your lecture.

Notes:

1. Since you are now free to move around, gesture, or point at different parts of the screen, it is useful to use lavalier (clip on) microphones instead of holding onto a hand-held microphone. Alternatively, you may simply use the built-in microphone of the webcam, but the audio quality is usually not optimal for a good lecture experience for the students.

2. During your lecture, you will have 3 separate screens in front of you, each serving a specific purpose:
   - The laptop shows only the full-screen lecture slides and is within comfortable reach of your hands to perform annotations, trigger animations, or to move to the next slide.
   - The LED monitor (with the webcam sitting on top) that carries the OBS Studio software will allow you to see the lecture content behind you and to view yourself in relation to the content, allowing you to accurately point at any given part of the screen. Your attention should be on this screen during the lecture, as it shows you exactly what students will see on their end. The moving bars at the bottom of the screen allows you to monitor the functioning of your microphone as well as the desktop audio (from played videos) that is projected to the students. Finally, the Zoom chat and participant windows may be moved to this screen as well.
   - The “Fullscreen Projector (Preview)” are on the other LED monitor. This provides the final chroma key composited video that is projected (i.e. screen shared) to students.
Performing Lecture Recording Locally using OBS Studio

- While recording of lectures is commonly performed using the streaming platform (e.g. Zoom), it is also possible to use OBS Studio to record only the “Fullscreen Projector (Preview)” window, where the video file is stored locally on the laptop.
- Only your chroma key composited lecture screen will be recorded, eliminating potential privacy issues that may emerge during a Zoom recording.
- This may be done by simply clicking the “Start Recording” button directly above the “Settings” button on the bottom right of the screen, as outlined and labelled as “1” in Figure 2.
- You may stop the recording entirely by clicking on the same button again, or to pause the recording by clicking on the pause button that appears on the right.
- The recorded lecture video file will be in mp4 format and appear in the file directory that you have indicated in the “Recording Path” in Figure 3.
- Note that this local recording function may potentially induce some lag in your stream and a high operational load on the laptop.