New Approaches in Technical and Engineering Education Utilizing Online and Computer Tools

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DOI: https://doi.org/10.47772/IJRISS.2026.10100088

Received: 28 December 2025; Accepted: 02 January 2026; Published: 22 January 2026

ABSTRACT

Computer and online learning are very crucial in training students in colleges and universities as they prepare to enter the workforce tomorrow. The use of computer tools can be expensive. However, enough resources seem to be available for students and educators to use for free. This should be incorporated into the classroom as preparation to perform in the real technical world where these tools may be useful to assist workers in solving technical problems.

INTRODUCTION

Nowadays, the use of computers in college education has become more prevalent as suggested in (Oguzor, 2011). Even after the pandemic, the use of computers and online resources has surged tremendously including for remote learning (Gabbiadini, Paganin, & Simbula, 2023). Many students become excellent at making presentations creatively and that in many respects contribute to increased performance in schoolwork. However, different challenges have come along such as the abuse of artificial intelligence (AI). Hence, part of the objectives in contemporary education is to minimize dependencies on AI in learning.

Solid Modeling and Analysis

Here, the focus is on several Computer Aided Engineering (CAE) solutions like Onshape (Onshape, 2025), Simscale (Simscale, 2025), and Valdivia (Valdivia, 2025). For a long time, SolidWorks has CAE tool of choice in many engineering sectors as reported by Martin in (Martin, 2023). Colleges also embrace SolidWorks in many teaching and learning activities (Rubin, 2022). Other schools like Purdue University and Universiti Teknikal Malaysia Melaka (UTeM) require students to sit for SolidWorks Certifications prior to graduation (Rudy & Webster, 2019). Another well-known CAE tool is Autodesk Inventor as indicated in (Primaversity, 2025) and (Dzhumaevich, 2020). Figure 1 shows the setting up for Onshape before a sketch can be made. The basic Onshape package is available for free. However, more advanced features including simulation and analysis would require some paid subscription.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue I January 2026

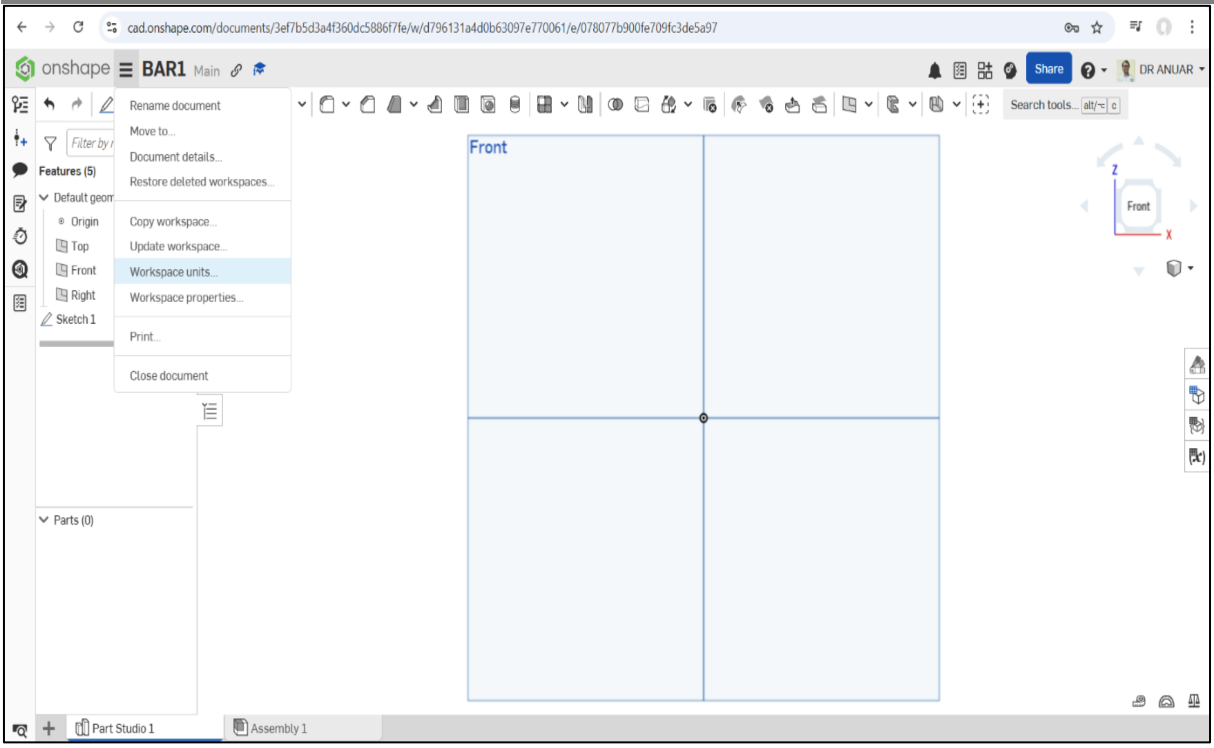

Figure 1. Preparing to sketch in Onshape by setting the units right.

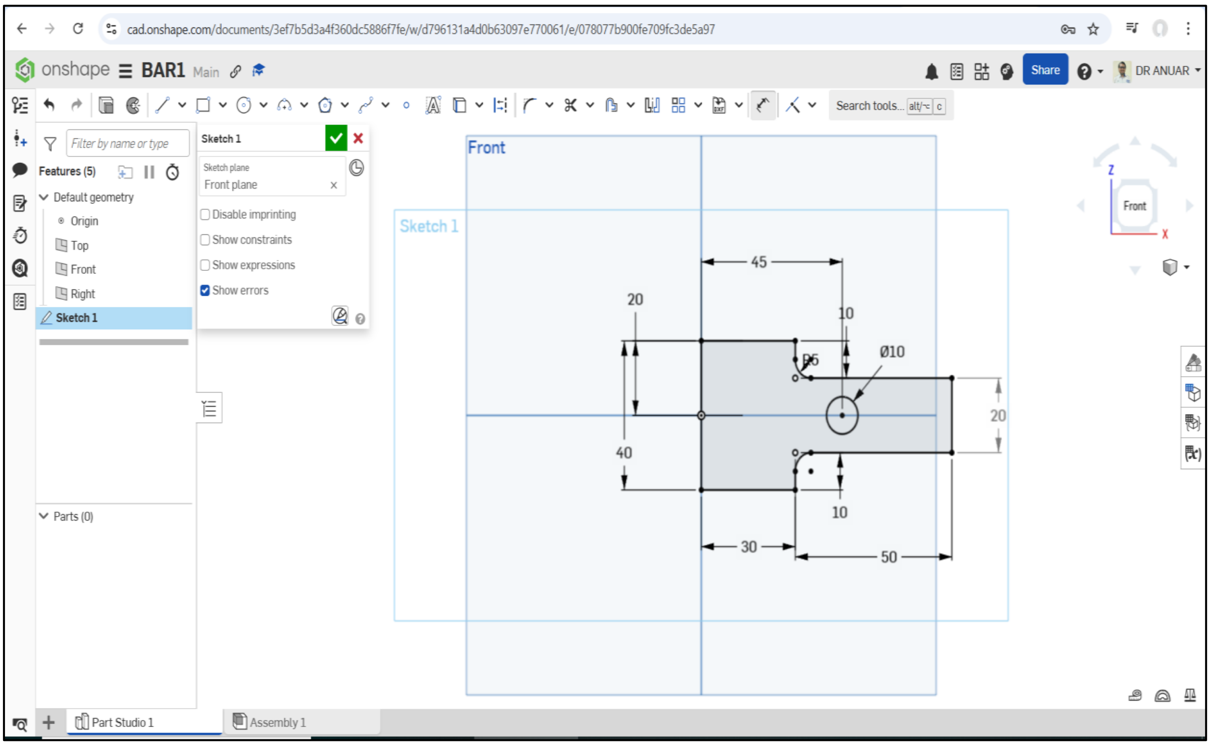

Figure 2. Preparing the sketch in Onshape before building the solid.

Just like in SolidWorks, the users must ensure the constraints and dimensions are complete. Next in Figure 3, the sketch is extruded to become a solid. The work in Onshape is automatically saved. To rotate the part around, use the right button on the mouse. For analysis, as mentioned before, the file from Onshape can be opened in Simscale as shown in Figure 4.

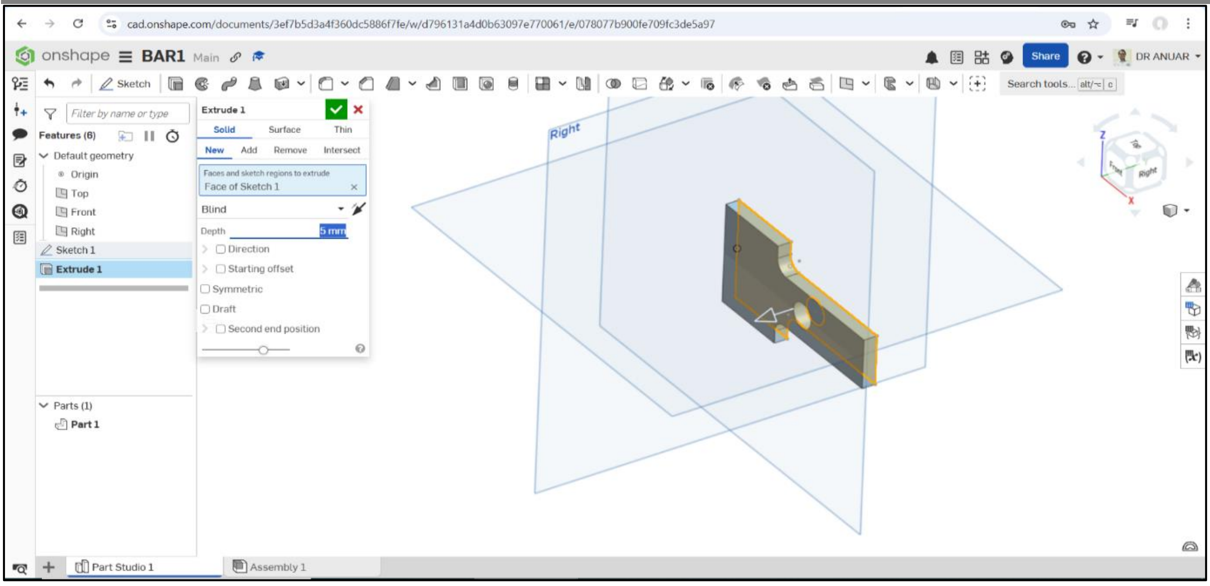

Figure 3. Preparing the sketch in Onshape before building the solid.

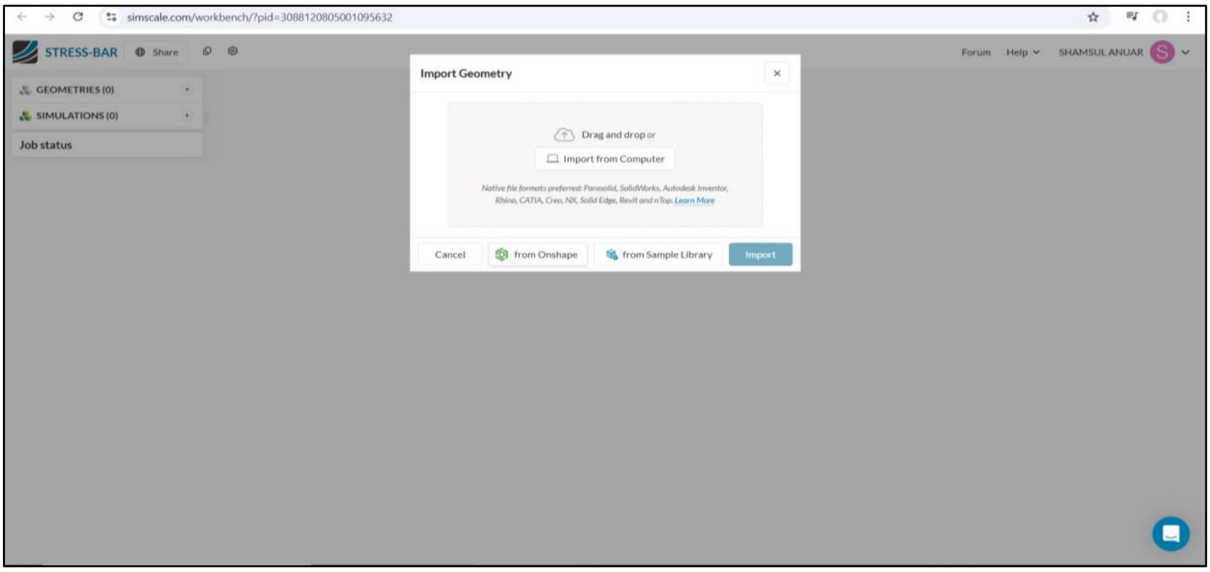

Figure 4. Continue in Simscale for analysis. See that files from Onshape can be retrieved for the analysis.

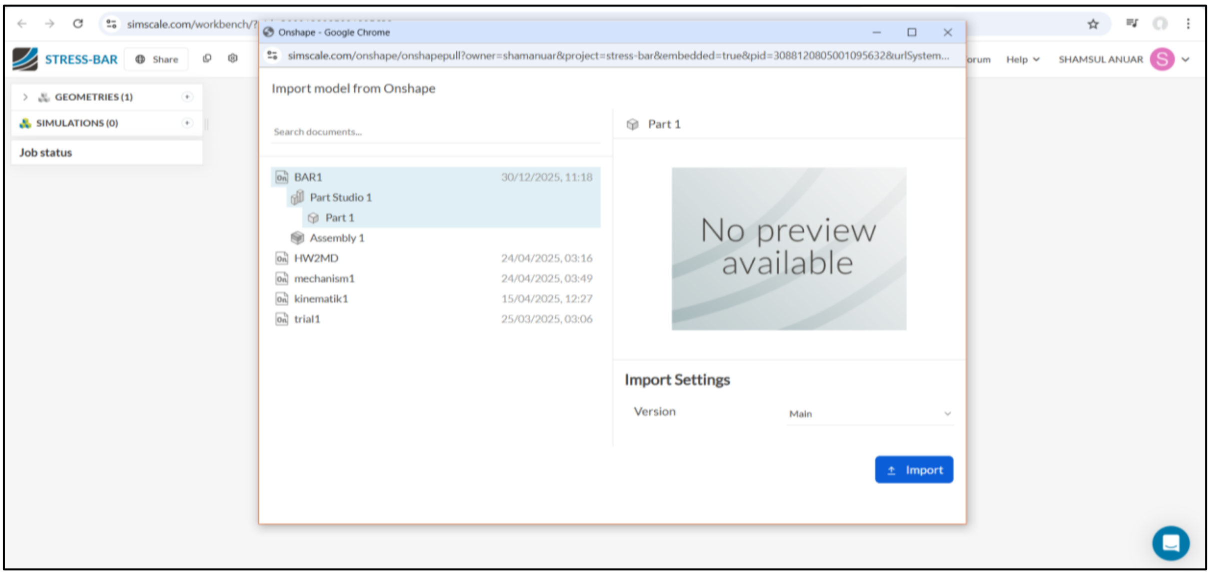

Figure 5. Importing the geometry from Onshape

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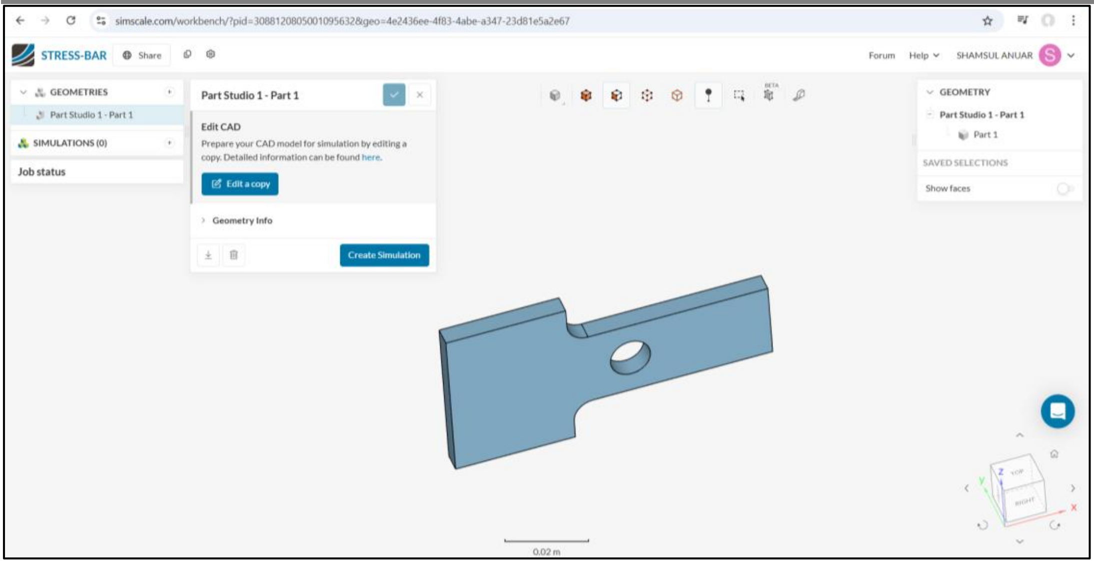

Figure 6. Continued in Simscale for analysis.

Figures 5 through 11 exhibit the preparation for running the simulation. Just like in SolidWorks, there is setting the fixed support, the force application, as well as the mesh generation. Then when everything is set, run the simulation. After that is done, we can observe the von Mises stress and the displacement to study the beam performance.

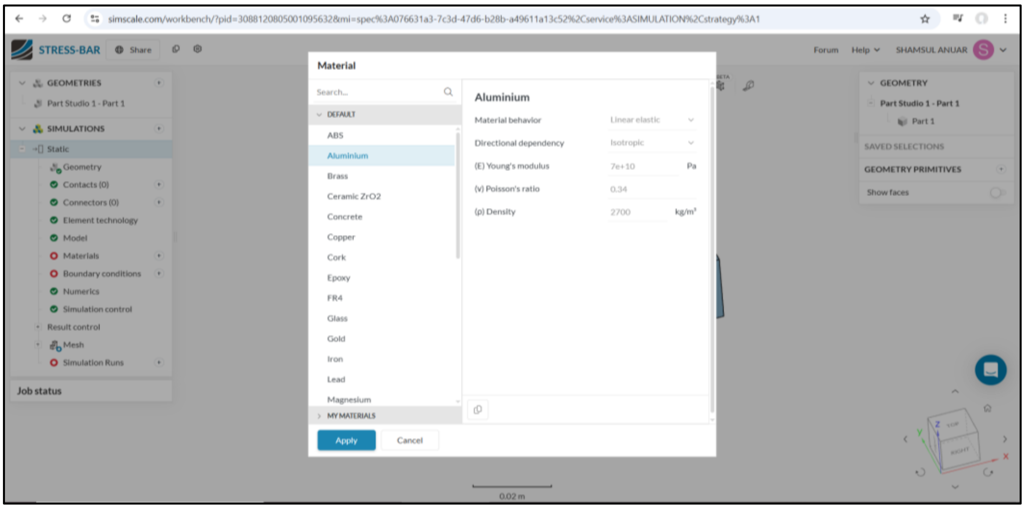

Figure 7. Choosing the material.

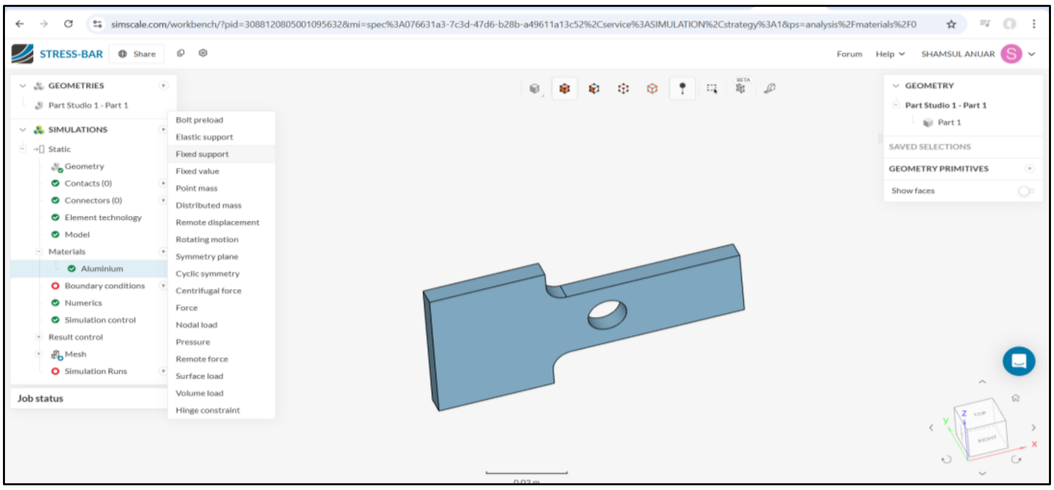

Figure 8. Several boundary conditions to set: fixed support and external force load.

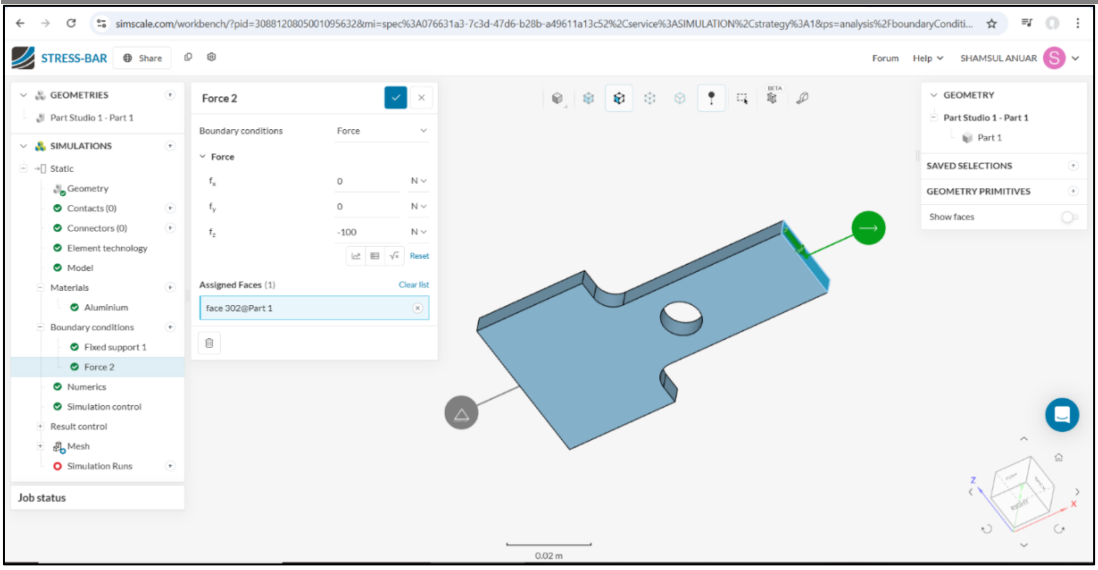

Figure 9. Input the required values.

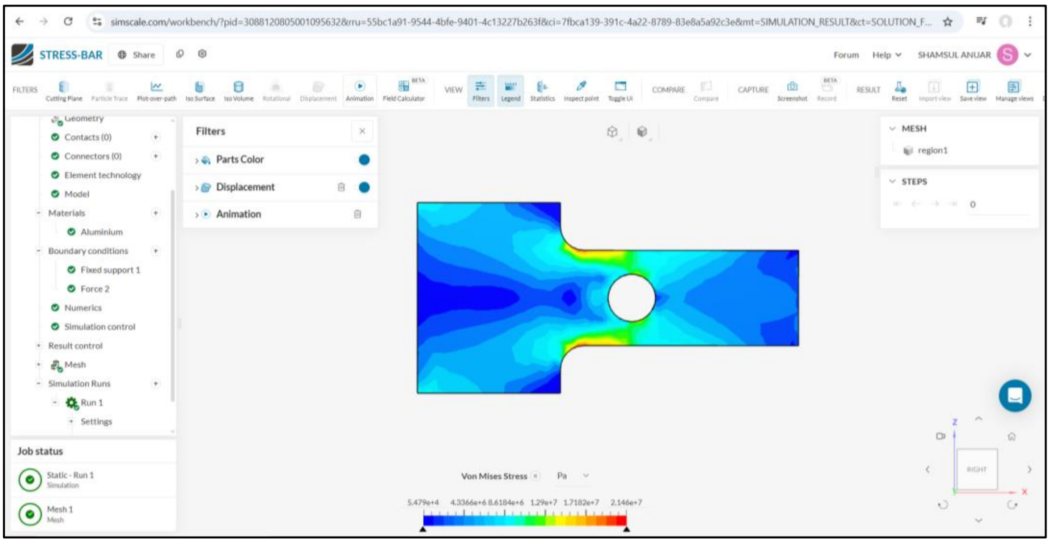

Figure 10. Post-processing Von Mises stress from Simscale.

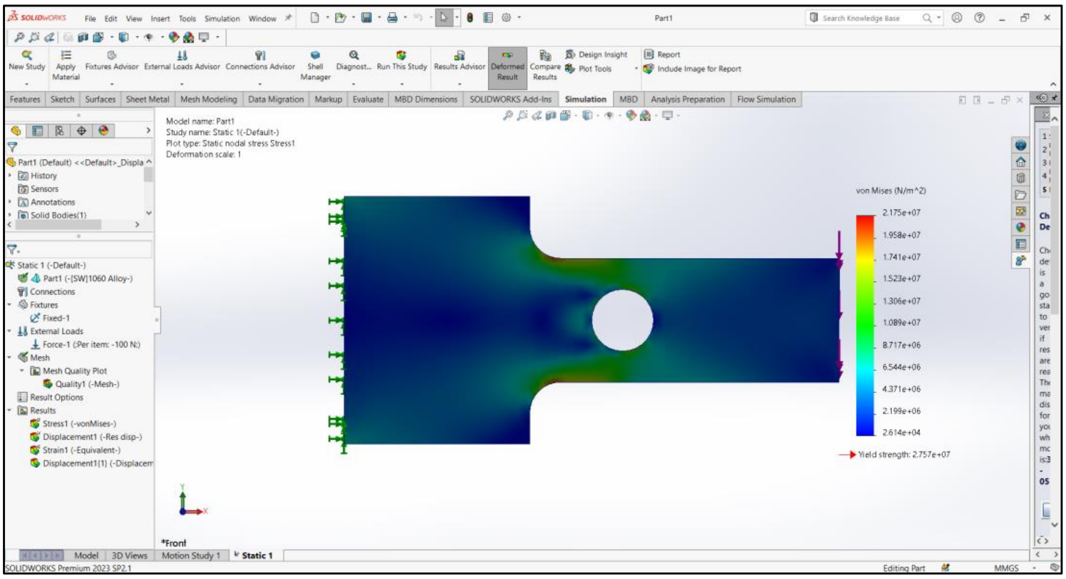

Figure 11. Post-processing Von Mises stress from SolidWorks.

INTERNATIONAL JOURNAL OF RESEARCH AND INNOVATION IN SOCIAL SCIENCE (IJRISS)
ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue I January 2026

From this case, we can see they both report the almost the same maximum stress values, which are 2.14 MPa and 2.17 MPa, respectively for Simscale and SolidWorks. They both identify the location of this maximum value near the top shoulder.

Programming With Freeware

In engineering and technology education, the use of computer coding using MATLAB is significant. Many schools would have campus-wide licenses so that their staff and students could install MATLAB on their own machines. However, MATLAB is expensive and many students and colleges may not have the budget allocation to use it as a tool. Fortunately, there are similar tools available such as the Octave. Users can use the exact script for MATLAB in Octave instead and it will run well. The following are the main script and a function. Figure 12 shows the output given by Octave, which is like that of MATLAB. This style of solution is popularized, among others, by Murray at the University of Dayton (Murray, 2011).

```
% MATLAB CODE FOR FOUR-BAR
% MECHANISM EXAMPLE - A CAR SUSPENSION
% Clean up the workspace
clear; clc; close all

R0 = [0; 0];
r1 = 14;
R1 = [0; r1];
theta2 = 195;
r2 = 8;
R2 = r2*[cosd(theta2); sind(theta2)];
r3 = 16;
r4 = 10;
r5 = 28;
r6 = 14;
Alpha = acosd((r3^2 + r6^2 - r5^2)/(2*r3*r6)); % degrees

%
ezplot('0 - 8 - 10*cos(t4*pi/180) - 16*cos(t3*pi/180)', [0 300 -20 340])
hold on; ezplot('14 - 0 - 10*sin(t4*pi/180) - 16*sin(t3*pi/180)', [0 300 -20 340])
% Make sure the figure containing the plot is the current active figure
figure(1);
[t3i, t4i] = ginput(1);
% Display the selected coordinates
disp('Selected coordinates (X, Y):');
disp([t3i, t4i]); cla
% Run fsolve optimization to get theta3 and theta4
[Output1, f] = fsolve(@(X) Solver4Bar(X,R0,R1,R2,r3,r4),[t3i t4i]);
% Initial angles are from ezplot or just smart guess!

% Solve the variables
theta3 = Output1(1);
theta4 = Output1(2);

% Identify the physical parameters

% Set the unknown vectors
R3 = r3*[cosd(theta3); sind(theta3)];
R4 = r4*[cosd(theta4); sind(theta4)];

% The plot
P1 = R1;
P2 = R1 + R2;
P3 = P2 - R3;
P4 = P3 - R4;
plot([3 0 0], [0 0 3], 'b-', 'linewidth', 3)
hold on
plot([P1(1), P2(1), P3(1), P4(1)], [P1(2), P2(2), P3(2), P4(2)], ...
    'k-', 'linewidth', 3)
hold on
grid on
plot([P1(1), P2(1), P3(1), P4(1)], [P1(2), P2(2), P3(2), P4(2)], 'ro', 'linewidth', 4)
axis([-25 10 -15 20])
```

```
% Optional labeling stuff
sketch_title = sprintf('Sketch of kinematic diagram at theta2 = %d degrees',theta2);
title(sketch_title)
xlabel('X')
ylabel('Y')
axis equal

% Locate the point of interest (POI)
theta6 = theta3 + Alpha;
R6 = r6*[cosd(theta6); sind(theta6)];
R5 = -R3 + R6; % From the BCD triangle ...
% Get the points
P5 = P3 + R6; % THE POINT OF INTEREST
P6 = P5 - R5;
hold on
plot([P3(1), P5(1), P6(1)], [P3(2), P5(2), P6(2)], 'k-', 'linewidth', 3)
hold on
plot(P5(1), P5(2), 'rp', 'linewidth', 4)  % the star that shows POI

function [F] = Solver4Bar(X,R0,R1,R2,r3,r4)

% Unpack our variables
theta3 = X(1);
theta4 = X(2);

% Build the unknown vectors
R3 = r3*[cosd(theta3); sind(theta3)];
R4 = r4*[cosd(theta4); sind(theta4)];

% Identify the loop to solve where success when F = 0
F = R0 + R1 + R2 - R3 - R4; % R0 is the origin.
```

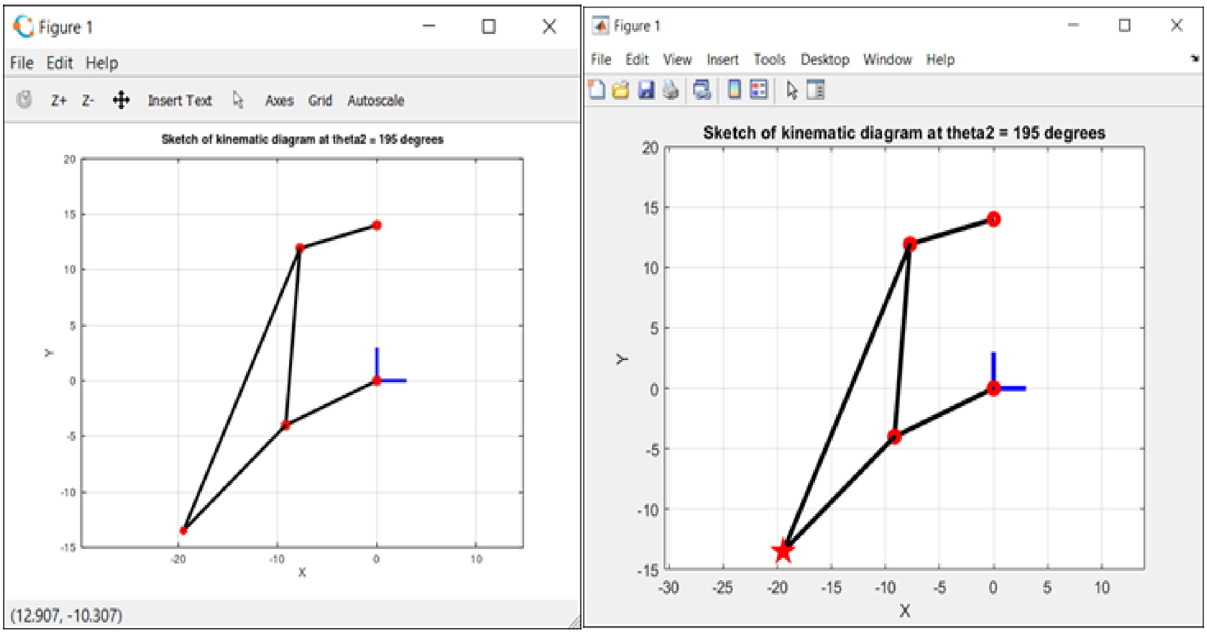

Figure 12. Graphical output from Octave and MATLAB based on the same script code and function.

Another challenging course in the technical and engineering curriculum is statics in mechanics. In so many instances, many students fail this course in their first or second year in college. One good source of reference for statics is (Baker & Haynes, 2025). Figure 13 shows a Klann mechanism of a walker. This problem requires the determination of torque at its actuator. Solving this problem by hand-calculations can be taxing. Hence, having a computer or an online tool can help alleviate the burden in the analysis. Figure 14 exhibits the analysis results Valdivia 2D Truss Analysis.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue I January 2026

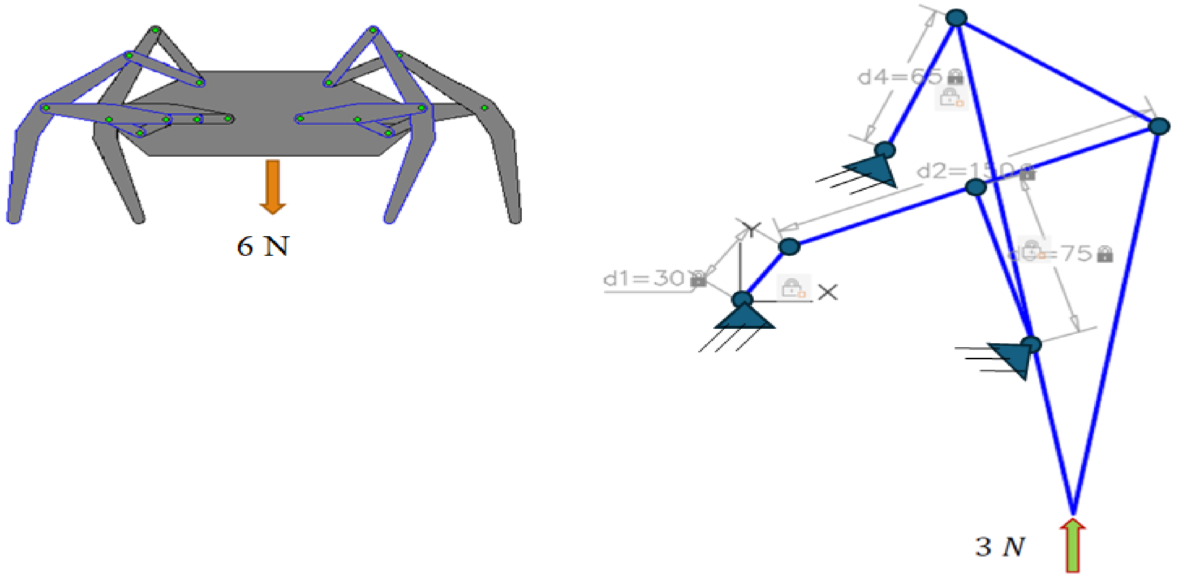

Figure 13. The Klann walker mechanism (Klann, 2011) and its free body diagram (FBD).

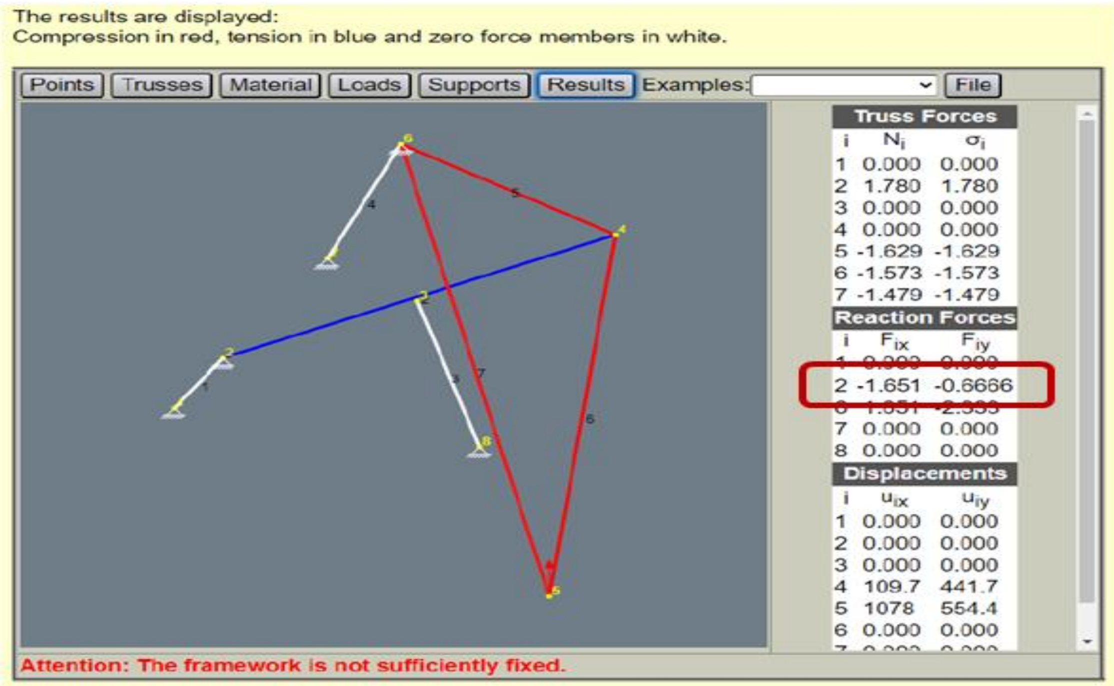

Figure 14. The Klann statics force analysis in (Valdivia, 2025).

The significance of doing this calculation is to find the torque at the actuator. In this case, that torque is about 0.28 Nm. This information will then help in selecting the right electric motor that would overcome its own weight as it starts to move.

Novel Approaches To Kinematics Teaching Using Cad

CAD is Computer Aided Design tool, which is a computer application software that allows users to draw engineering graphics efficiently. These technical drawings are crucial in making building plans, guidance for parts fabrications and assembly, as well as preparation for further analysis and simulations. The popular 3D printing technology also depends on the data from CAD.

However, there are many brands and models of CAD systems in the market. One of the most popular ones is AutoCAD by Autodesk. The teaching of kinematics course at the Universiti Teknikal Malaysia Melaka also utilized AutoCAD. Here, a case study is considered where a wheelchair is to be lifted onto the stage via a linkage mechanism. Three positions are used in the synthesis and locations of two fixed pivots are known on the floor of the hall as shown in Figure 15. Similar synthesis discussion can also be found in (Youssefi, 2014).

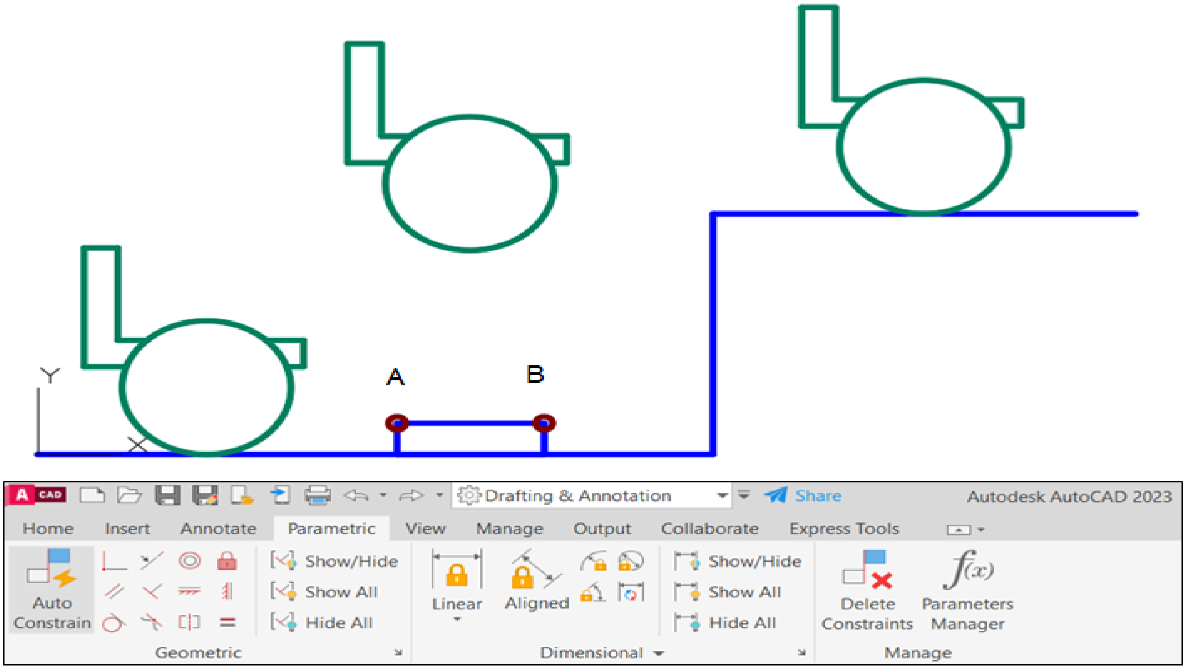

Figure 15. The wheelchair in three positions and fixed pivots A and B. Also shown is the Parametric ribbon that hosts many features to constraint movements.

The basic synthesis for three positions requires that linear lines connect point P in the 3 positions. From there, two perpendicular bisectors are made at extended until they intersect at C, as indicated in Figure 16. We shall repeat the same process for point Q in the 3 positions, and this results in a fixed pivot at D. Nevertheless, having the fixed pivots at C and D is undesirable since they are beneath the floor. Hence, we move pivot D to point B, whereas pivot C is moved to point A. The vectors that allow the transfer, also moves the moving pivots P and Q to R and S as evident in Figure 17. Here, Parametric features in AutoCAD are very effective in locating the pivots.

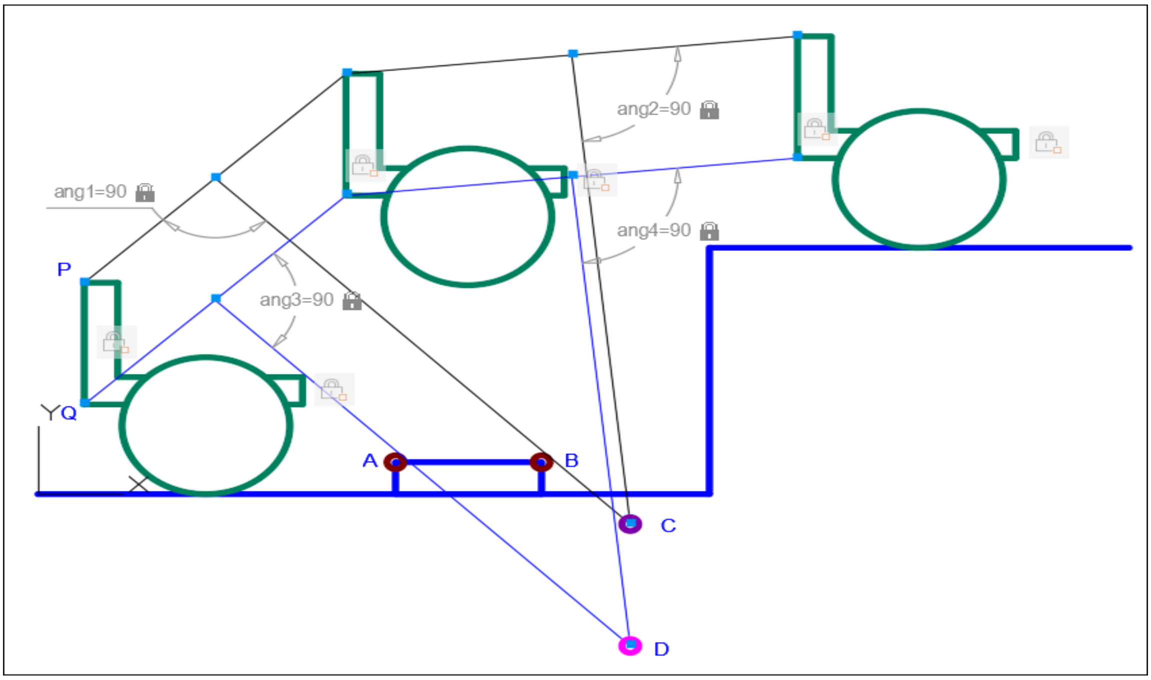

Figure 16. The resulting fixed pivots C and D are well in the ground.

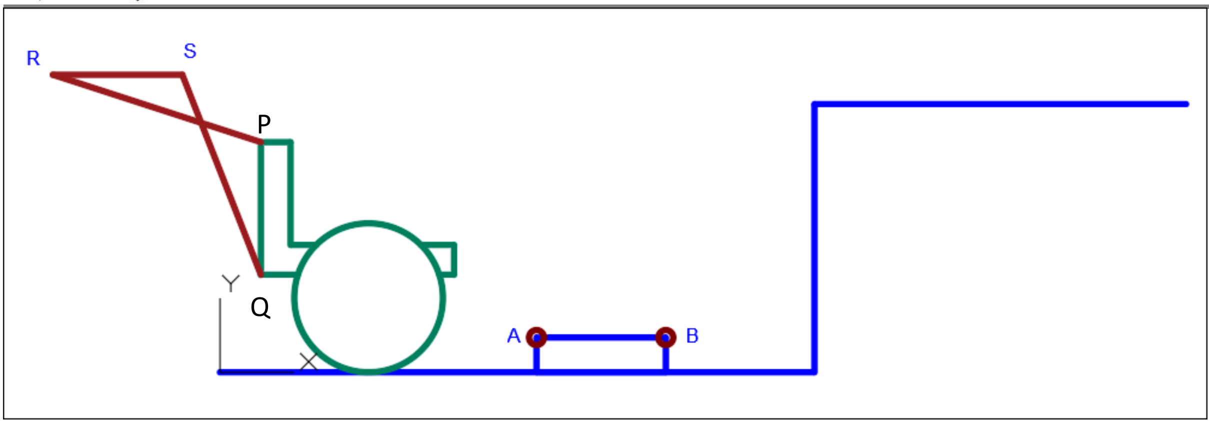

Figure 17. The new moving pivots R and S.

The next step is to complete the mechanism by adding two dyads AR and BS. Again, use the Parametric features and then the mechanism can be tested to move through the three positions as required in the design. Figure 18 shows mechanism successfully transport the wheelchair through the 3 positions with the correct orientation, while operating from the desired pivots A and B.

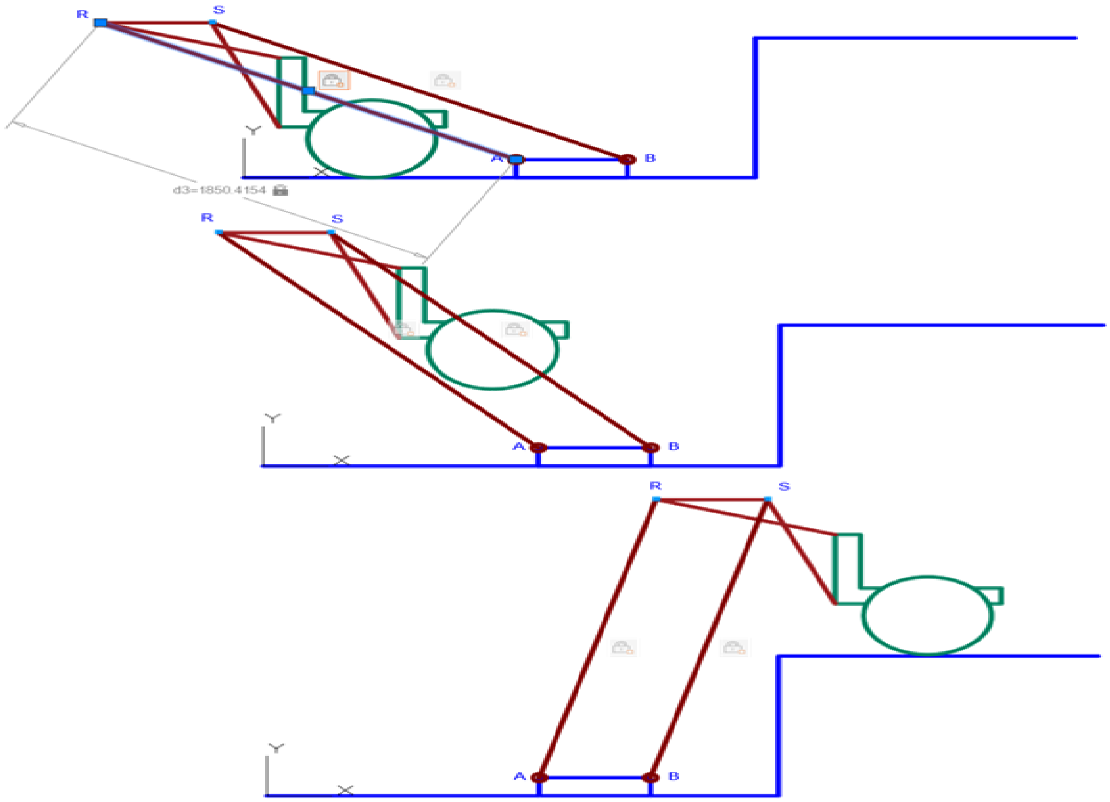

Figure 18. The mechanism moving through the different positions.

Free Citation Maker Tools

Technical and engineering students are always tasked with a lot of writing assignments and project reports. Among the important parts of the writing work are citations and reference lists according to the instructors who give those assignments. Take the American Psychological Association (APA) for instance. When searched, there are many resources offering guidelines or some applications that can generate citations and references automatically such as in (MyBib, 2025). Another good tool is shown in Figure 19 (Citefast, 2025). However, if Microsoft Word is used as the word processor, the settings can be accessed from this cluster of functions shown in Figure 20. The preview of the reference list can be previewed as shown in Figure 21. Despite the availability of various resources, students still make mistakes in writing citations and references.

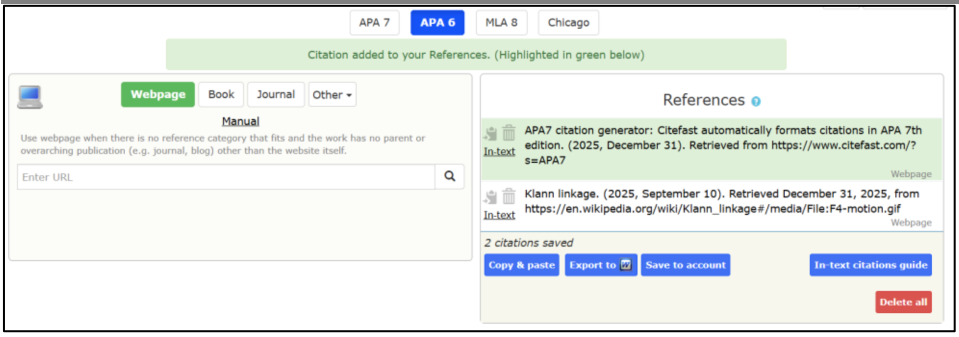

Figure 19. The tool from (Citefast, 2025).

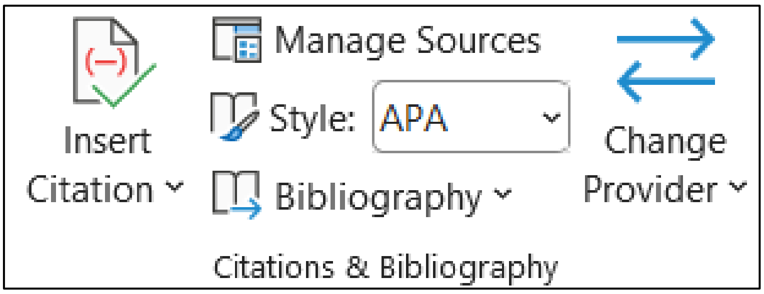

Figure 20. The citations & Bibliography features in the References ribbon in Microsoft Word.

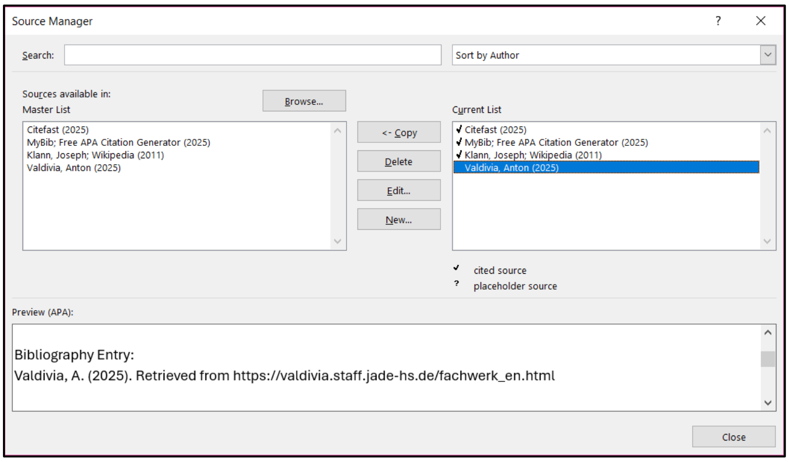

Figure 21. The citations & Bibliography features in the References ribbon in Microsoft Word.

CONCLUSION

Technical and engineering students can learn the knowledge and skills needed to master the industry of tomorrow. While many software, apps, and resources can charge hefty fees, there are still some that are available for free. It is perhaps a good idea to expose students to these tools that are just as good so that they might come in handy to solve technical problems after the students have joined the workforce.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to the Universiti Teknikal Malaysia Melaka for their contribution and encouragement in publishing scholarly works such as this article.

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