FAKULTI KEJURUTERAAN MEKANIKAL

UiTM CAWANGAN PULAU PINANG

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MEA 301

INTRODUCTION TO AEROSPACE ENGINEERING

GLIDER DESIGN PROJECT

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1.0 INTRODUCTION TO GLIDER

1.1 Define Glider

A glider is a heavier-than-air aircraft that is supported in flight by the dynamic reaction of the air against its lifting surfaces, and whose free flight does not depend on an engine.

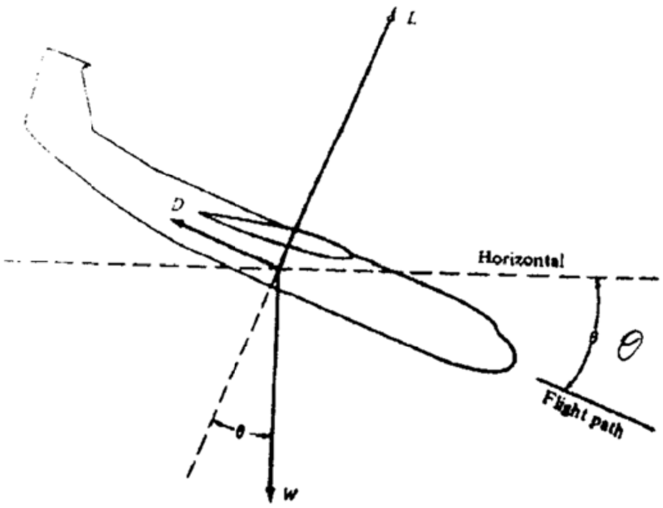
As for our glider project we used balsa wood, cupboard foam, sheet metal, carbon fiber rod and plasticine. The reason why we used balsa wood as for the main body for our glider is because it is lighter than any other wood. Next is for the cupboard foam. We used it for the wing and tail of our glider. We used it instead of other material is because cupboard foam tend to be the lightest cupboard so that our glider will be easy to fly in the air. We design our wing to swept back shape due to lengthen the gliding time, so that our glider will be flying in the air for a long time. Same goes to the tail. The material is as same as the wing but for the shape we choose the conventional tail and it must be at the angle of 90 degree. The reason why we make it a conventional tail is due to provide more stability during gliding. The orientation of the glider will go straight instead of pitching or rolling. The wing and tail must be in rigid position so we put stainless steel and carbon fiber rod along the wing and tail length so that it would not wobble and both side of the wing and tail will be in a straight line. The wing and tail must be in rigid position if we want to reduce rolling during glide. Lastly, for the plasticine, we attached it at the nose of our glider due to avoid extreme pitch up and down. We used it to balance the glider during gliding.

1.2 Gliding Performances

Consider an airplane in a power-off glide, as sketched in figure below. The forces acting on this aircraft are lift, drag, and weight; the thrust is zero because the power is off. The glide flight path makes an angle below the horizontal. For an equilibrium unaccelerated glide the sum of the forces must be zero. Summing forces along and perpendicular to the flight path, we have:

(along to the flight path) $D = W \sin\theta$ Equation 19

(perpendicular to the flight path) $L = W \cos\theta$ Equation 20



The equilibrium glide angle can be calculated by dividing Eq. 19 by Eq. 20, yielding

$$\frac{\sin\theta}{\cos\theta} = \frac{D}{L}$$

$$\boxed{\tan\theta = \frac{1}{L/D}}$$ Equation 21

Clearly, the glide angle is strictly a function of the lift-to-drag ratio; the higher the L/D, the shallower the glide angle. From this, the smallest equilibrium glide angle occurs at (LID)max which corresponds to the maximum range for the glide.

2.0 GLIDER SPECIFICATIONS

2.1 Drawing

The figure above shows the actual-size drawing (dimensions included) of the glider on four-attached papers. Following are the general specifications of the glider:

i Wing root chord: 280 mm

ii Wing tip chord: 160 mm

iii Wing sweep distance: 210 mm

iv Wing half span: 750 mm

v Stabiliser root chord: 120 mm

vi Stabiliser tip chord: 100 mm

vii Stabiliser sweep distance: 50 mm

viii Stabiliser half span: 200 mm

ix Distance between both leading edges: 600 mm

x Stabiliser efficiency: Standard

xi Static margin: 15%

Based on the dimensional preferences above, the resulting specifications are as follow:

i Mean aerodynamic chord: 225.5 mm

ii Sweep distance at mean aerodynamic chord: 95.5 mm iii From root chord to mean aerodynamic chord: 340.9 mm

iv From wing root leading edge to aerodynamic center: 151.8 mm

v From wing root leading edge to neutral point: 176 mm

vi From wing root leading edge to center of gravity: 142.2 mm

vii Wing area: 3.3×10^5 mm^2

viii Stabiliser area: 4.4×10^4 mm^2

ix Wing aspect ratio: 6.82

x Tail volume ratio: 0.3

2.2 Specifications

The figure above shows the computational calculation that has been done throughout the course of the project assignment. Following is a table of range of the weight approximation and the resulting cubic loading as well as stall speed:

Weight (g)	225	300	333	500	760
Cubic Loading (oz/ft^3)	1.18	1.58	1.76	2.64	4.00
Stall Speed (km/h)	11.9	13.7	14.5	17.7	21.9

The weight of the glider is approximately 333 gram. Given its large wing span and big wing area, the cubic loading is outstandingly only at 1.76 at the particular weight.

2.3 Calculations

Over the course of the project assignment, the calculations that have been attempted are gliding flight equations and thrust as well as power required equation. Following are the sample of calculations that have been done:

i Gliding Flight

Assuming the weight of the glider is 333 gram,

$$W = mg$$

$$W = \left(\frac{333}{1000}\right) kg \cdot 9.81\ ms^{-2}$$

$$\mathbf{W = 3.27\ N.}$$

Taking the discrepancies into account with a consideration of $\theta = 1°$,

$$D = W \sin\theta$$

$$D = (3.27)\ N \cdot \sin 1°$$

$$\mathbf{D = 0.057\ N.}$$

Also,

$$L = W \cos\theta$$

$$L = (3.27)\ N \cdot \cos 1°$$

$$\mathbf{L = 3.27\ N.}$$

Glide angle,

$$\theta = \tan^{-1}\frac{1}{(\frac{L}{D})}$$

$$\theta = \tan^{-1}\frac{1}{(\frac{3.27\ N}{0.057\ N})}$$

$$\boldsymbol{\theta} \approx \mathbf{1}°.$$

ii Thrust and Power Required

Thrust required,

$$T_R = \frac{W}{(\frac{L}{D})}$$

$$T_R = \frac{3.27\ N}{(\frac{3.27\ N}{0.057\ N})}$$

$$\mathbf{T_R = 0.057\ N.}$$

Power required,

$$P_R = T_R\ V_\infty$$

$$P_R = (0.057)\ N \cdot (4.03)\ ms^{-1}$$

$$\mathbf{P_R = 0.23\ W.}$$

3.0 GLIDER DEVELOPMENT

i The measurements calculated earlier were transferred and outlined on two pieces of cardboard foam.

ii The cardboards were cut according to their actual dimensions and the final products were two symmetrical wings, two symmetrical tails and one vertical stabilizer.

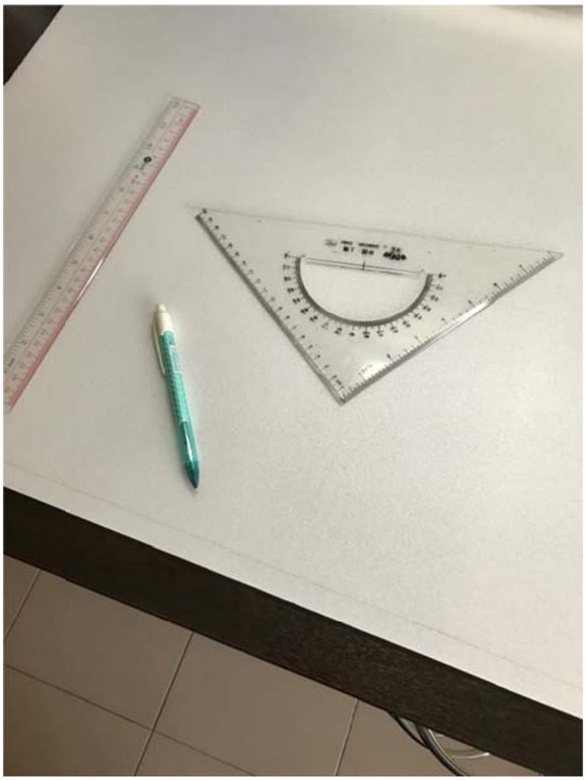
iii A metal strip that was given to us was shaped according to the dimensions of the stick that acted as the fuselage to the glider; this is because the metal strip will provide more stability to the wings hence making them more rigid.

iv The metal strip was glued underneath both of the wings using a hot glue gun and then attached to the stick, exactly on the point of the center of the gravity that had been calculated earlier.

v The two symmetrical tails and a horizontal stabilizer were then attached perpendicular to each other, forming a conventional tail. This action was done by again, forming a set of metal strips to an angle of 90° and attaching each of it to each perpendicular sides.

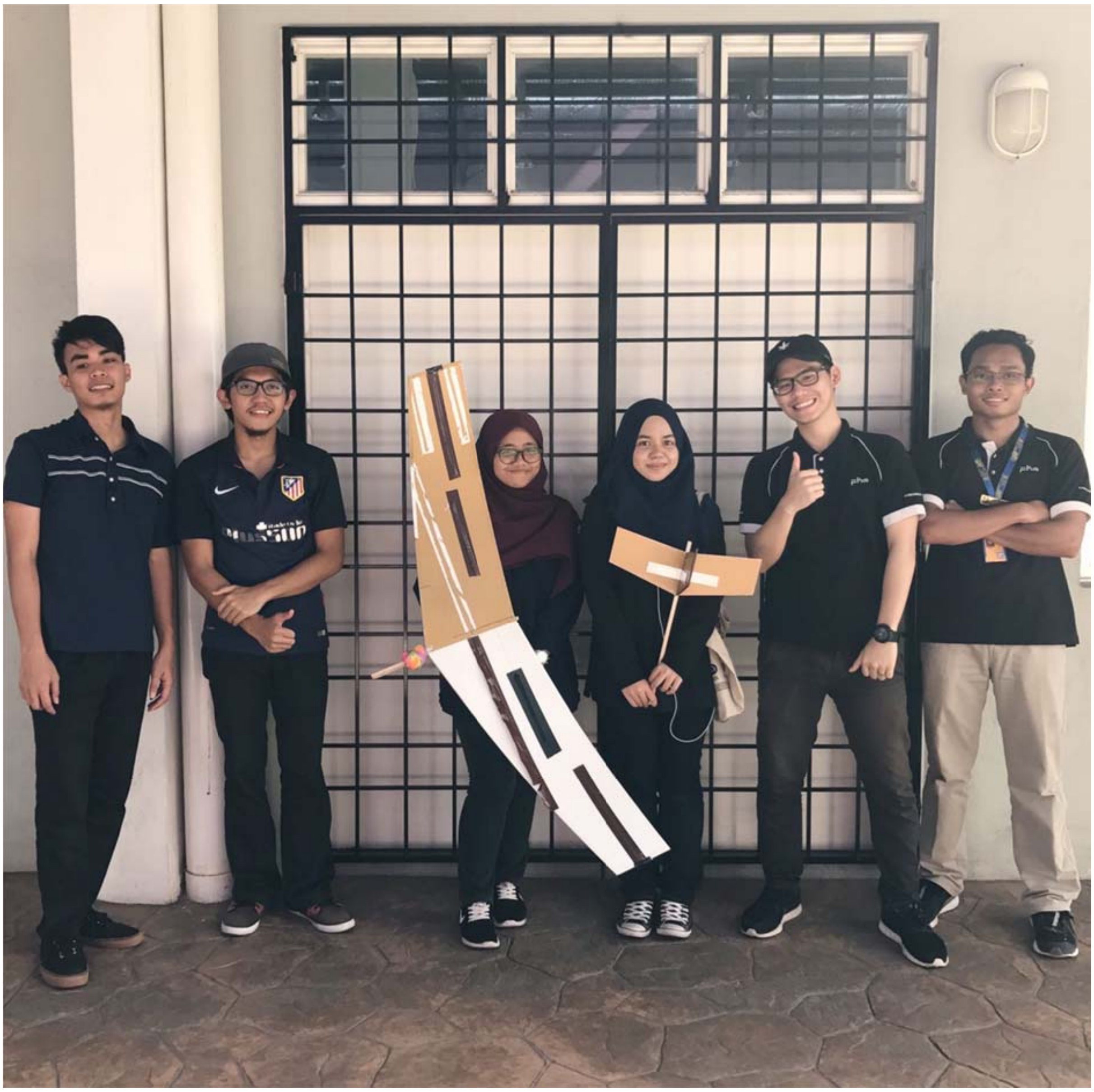
vi To add more rigidness and ensure that the wings are stiff enough, we horizontally added a carbon rod and a string on top of the wings.

vii Lastly, we added some weight to the front section of the glider, near to the center of gravity. This was to ensure that the glider will not exaggeratedly pitch up or pitch down.



4.0 GLIDER

Complete gilder before test flight.



Complete gilder after test flight.

5.0 TEST RESULT

5.1 Stability Test

Due to some technical difficulties, we were not able to perform the practical stability test inside Dewan Besar. Because of that we decided to only make the range test flight. Before this we already had do some theoretical stability test by hanging the gilder's centre of gravity on a thread and we were able to counter balance the tail's weight by adding some extra weight on the trailing edge, the amount of weight we added was 320 grams. We used plasticine as the medium of the weight.

5.2 Range Test

i **Range Test Outdoor (1st Test)**

The attempt was apparently a failure due to wind turbulence and not enough thrust.

ii **Range Test Indoor (1st Test)**

The attempt was the most successful of all.

iii **Range Test Indoor (2nd Test)**

The attempt had ended up with a catastrophe to the glider in which the glider had broken into two pieces upon hitting a table nearby.

6.0 CONCLUSION

As a conclusion to our gilder project, we were able to finish our project in given time. We started with a design that consist of multiples swept, but as we refer the design to our lecturer, we found that the design is not suitable because it is hard to make our wing rigid. Then we decided to change the design with a more simple design, we choose a design with no wing swept, after completing the gilder with the 2nd design we were not able to achieve the cubic loading that is necessary for a gilder which is below 4.00, we analyse the problem and found out it is because of our wing is too small and had no swept. Then finally we come out with the 3rd design after analysing all the problems that we had with the previous design and come out with a better one. Our design is exactly like the one we mentioned in the gilder specs section. The design was successful, and we were able to make it glide.