

**UNIVERSITI TEKNOLOGI MARA**

**ASSESSING MULTIPLE APPROACHES AND  
VARIOUS HYPERELASTIC MODELS FOR  
BIOMECHANICAL PROPERTIES OF ANIMAL  
SKIN**

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Thesis submitted in fulfilment  
of the requirement for the degree of  
**Doctor of Philosophy**

**Faculty of Mechanical Engineering**

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## **CONFIRMATION BY PANEL OF EXAMINERS**

I certify that a panel of examiners has met on 29<sup>th</sup> December 2015 to conduct the final examination of Nor Fazli Bin Adull Manan on his Doctor of Philosophy thesis entitled “Assessing Multiple Approaches and Various Hyperelastic Models For Biomechanical Properties of Animal Skin” in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiners recommends that the student be awarded the relevant degree. The panel of Examiners was as follows:

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## **AUTHOR'S DECLARATION**

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research

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## ABSTRACT

The importance of understanding skin behaviour, either in biological domain or engineering field has led to many researches. Researches about the anisotropic and viscoelastic behaviour were carried out on human, animal or synthetic skin. The simple structure can look from outside, but complex anatomy when study in details under the skin layer. The complicated behaviour of skin such as highly non-linear, viscoelastic, inhomogeneous and anisotropic clearly shows the complexity behaviour of skin, especially when measuring and quantifying its bio-mechanical properties. Therefore, this research aims to quantify the Bio-Mechanical properties of animal's skin via multiple approaches and adapting various hyperelastic constitutive models. Systematic methodology employed in this research starts with the experimental approach (in-vitro mechanical testing) followed by the analytical approach (theoretical derivation) then numerical approach (computational parameter quantification) and finally Finite Element simulation (skin model simulation). Each approach was analysed three different animal's skin (bovine, ovine and leporine) as the main subject individually. All approaches and animal skins were adapted with three hyperelastic constitutive models (Mooney-Rivlin, Neo-Hookean and Ogden model) for comparison purposes. It is found that the Ogden model and numerical approach are the best studied model and approach in choosing the suitable analysis procedure of animal skin or skin like materials. The results and finding prove that the current study is significant and has contributed to knowledge enhancement about the deformation behaviour of the animal's skin.

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