

Beyond the Equations: Mathematics in Action for Real-World Challenges

Mini-Symposium 2024 – Department of Mathematics
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Matara
Sri Lanka

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Mini-Symposium 2024!

- Mini-symposium? Why “mini”?
- Real-world impact of your projects.

Your Research



Massive!!!

- The Ordinary Kriging method for prediction of the positive spread of Covid-19 in Galle District.
- Analysis of indoor air pollution by using LU decomposition.
- Estimation of Value-at-Risk (VaR) using Random Forest Model.
- Life Expectancy Prediction using Multiple Linear Regression.
- Mathematical Model for Motor Insurance Claim Using Decision Tree.
- Determination of the Shortest path for an Airplane Using Dijkstra's Algorithm.
- Four compartment mathematical model for diabetes population dynamics.
- Image compression of Victoria creator with Principal Component Analysis.
- Modelling time series data using exponential smoothing methods.
- Using Numerical Integration Methods to find the Water Plane Area of a ship.
- A Java-based Implementation on Two Group Discriminant Analysis.
- Population modelling with differential equations
- Factors Affecting Motor Insurance Claim.
- Applications of Monte Carlo Method.
- Classify the quality of Latex in Rubber using Support Vector Machine.
- Modelling and Forecasting the Sri Lankan Exchange Rate using Time Series Analysis.

Hidden Impact of Mathematical Research

Bridging the Gap:

- **Mathematics acts as a bridge, connecting theoretical concepts to practical, everyday challenges faced by industries.**
- **The goal is to bridge the gap between abstract mathematical equations and their tangible, impactful applications.**



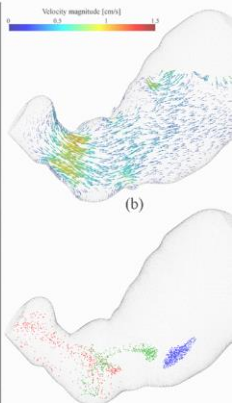
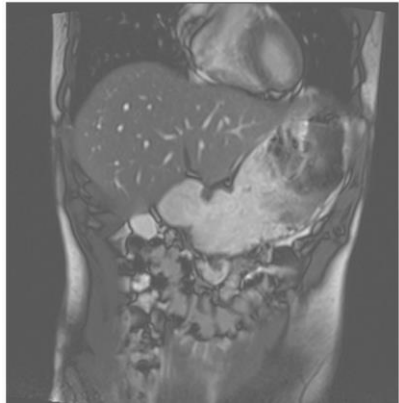
From Classroom to Industry

- Your research should extend beyond the university, demonstrating the transition from theoretical learning to hands-on problem-solving in real-world contexts.
- Mathematical models are not confined to academic exercises; they hold the ***potential to transform industries and address pressing global issues.***

Unlocking Potential - Examples from Drug Development

Your research may serve as a key to unlocking this potential, revealing the power of mathematics in unexpected areas.

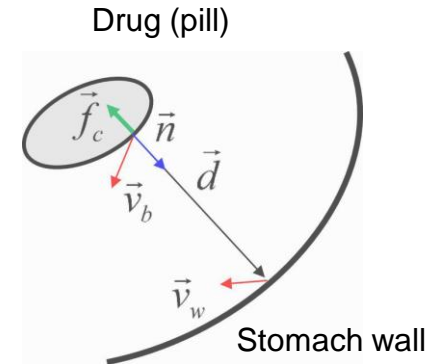
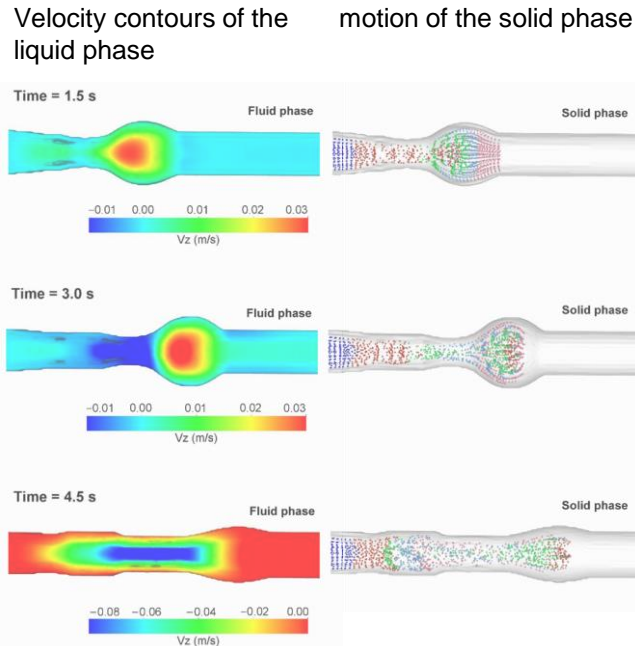
A Systematic Review of Computational Fluid Dynamics Models in the Stomach and Small Intestine.



U = flow velocity,
 t = time,
 ρ = fluid density,
 μ = fluid viscosity,
 p = fluid pressure,
 f = additional body forces (e.g., gravity).

$$\frac{\partial u_i}{\partial t} + u_j \frac{\partial u_i}{\partial x_j} = -\frac{1}{\rho} \frac{\partial p}{\partial x_i} + \frac{\mu}{\rho} \frac{\partial^2 u_i}{\partial x_j^2} + f_i \quad \text{conservation of momentum}$$

$$\partial u_i / \partial x_i = 0$$



Total contact force and moment:

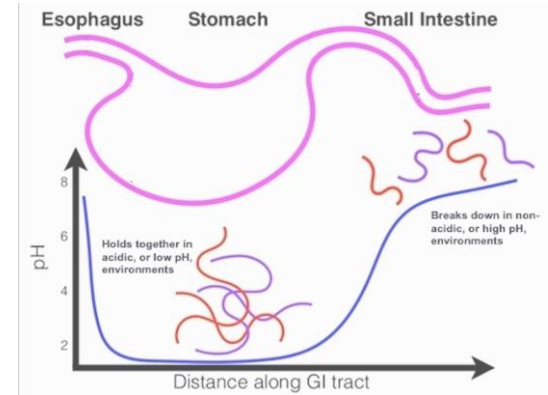
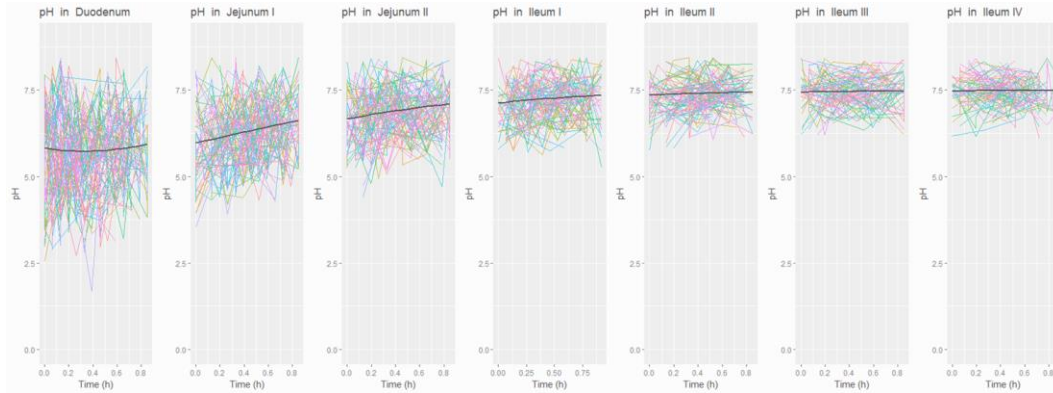
$$\vec{F}_c = \int_{S_P} \vec{f}_c dS, \quad \vec{M}_c = \int_{S_P} \vec{r} \times \vec{f}_c dS.$$

Drug dissolution

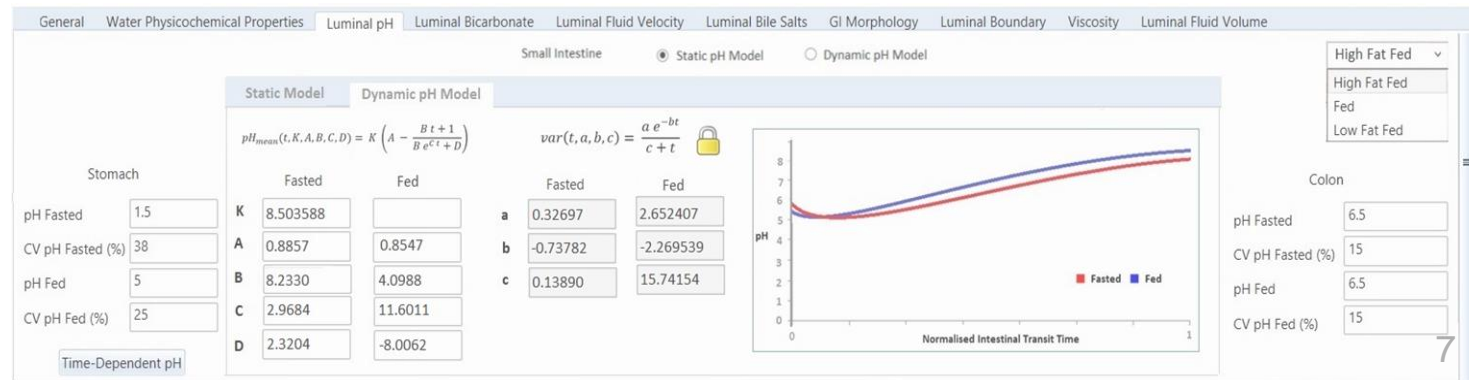
$$\frac{\partial C_{API}}{\partial t} + (\vec{u} \cdot \nabla) C_{API} = D \nabla^2 C_{API}$$

Probability and Statistics in action...

Variation of pH in Small intestine in fasted state

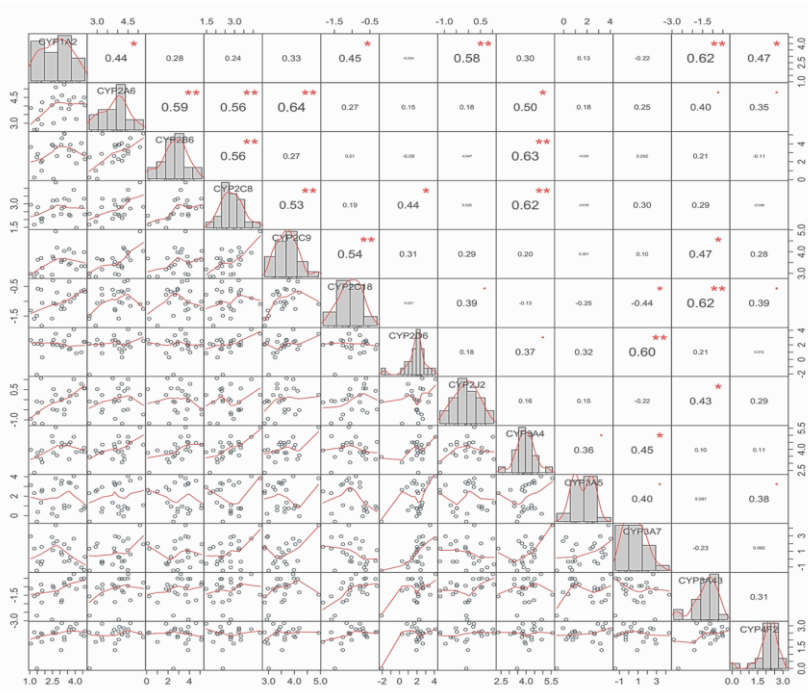


Computer simulations guide how to design a tablet that can efficiently absorbed into the blood via portal vein to liver.



Probability and Statistics in Action...

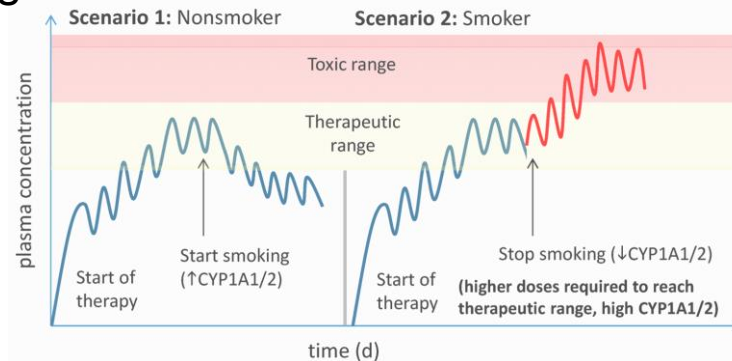
Population variability in drug metabolizing enzyme levels in liver



Tobacco smoke can induce liver enzymes, affecting drug metabolism. Some medicines may need dose adjustment or monitoring if a person stops or starts smoking.

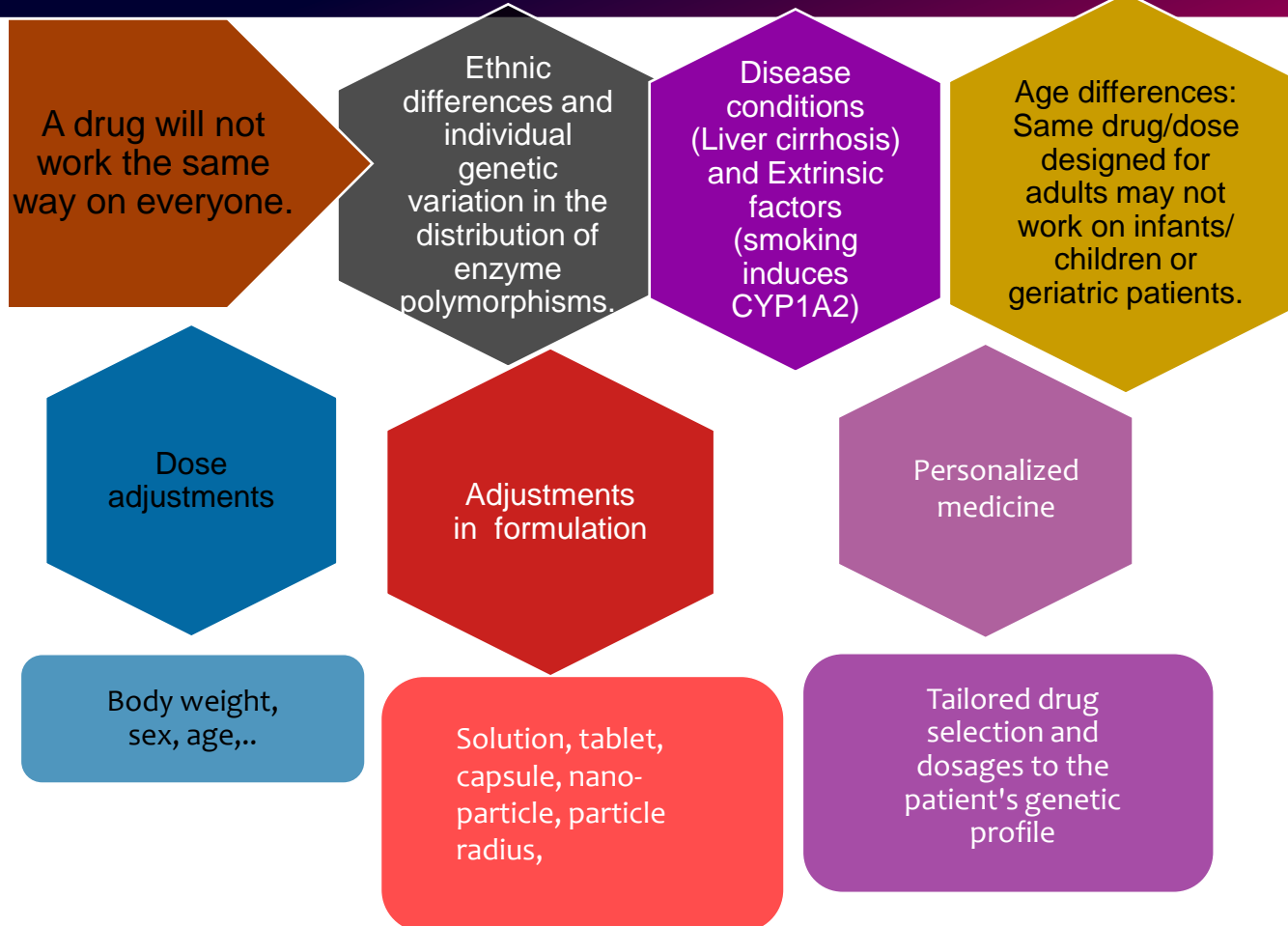
Smoking and some environmental factors causes the level of some enzymes to increase

- ⇒ The drugs metabolized by those enzymes will be quickly 'cleared'.
- ⇒ Higher dose is required to get the effect of the drug.

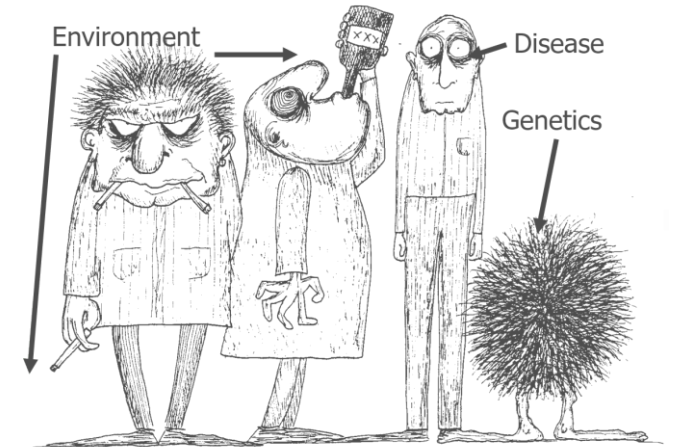


- Patients with liver or kidney disease will have different enzyme levels!
- Not all ethnicities in the world have the same population mean of drug metabolizing enzymes!

Why drugs have different effects on individuals?



Each one of us is unique!!!



<https://www.slideshare.net/mjamei/an-introduction-to-in-vitro-in-vivo-extrapolation-ivive>

Question:

How to incorporate various types of patient variability in the models?

Probability and Statistics in Action...

- How do we incorporate the variability in ODE models?
- First, we should understand the sources of variability.
 - E.g. Two individuals have different levels of serum creatinine, or kidney function (GFR). This will be a parameter θ (random) in the model: $dy/dt = f(t, x, \theta)$ with

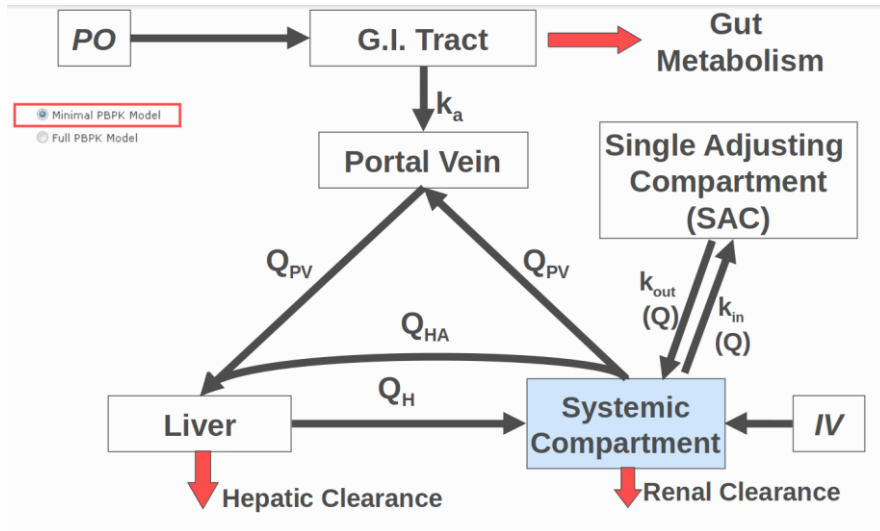
$$\theta = \theta_{population} + \eta$$

- Additionally, we can have measurement or analytical errors.
- If the solution to the ODE is $y = F(t, x, \theta)$, then the solution with variability in individual parameters and the measurement error can be written as $y = f(t, x, \theta) + \epsilon_i$

Here, $\theta_i \sim N(\theta_{population}, \omega^2)$, $\eta \sim N(0, \omega^2)$, and $\epsilon \sim N(0, \sigma^2)$.

Physiology Based Pharmacokinetic (PBPK) Models

A Minimal PBPK Model



Systemic compartment:

$$\frac{d}{dt} C_{sys} = \frac{1}{V_{sys}} \left(\frac{Q_h C_{Liv}}{K p_{Liv}/BP} - Q_h C_{sys} - \frac{CL_R}{BP} C_{sys} \right)$$

Liver compartment:

$$\frac{d}{dt} C_{Liv} = \frac{1}{V_{Liv}} \left(Q_{pv} C_{pv} - \frac{Q_h C_{Liv}}{K p_{Liv}/BP} + Q_{ha} C_{sys} - Cl_{intH} fu \frac{C_{Liv}}{K p_{Liv}} \right)$$

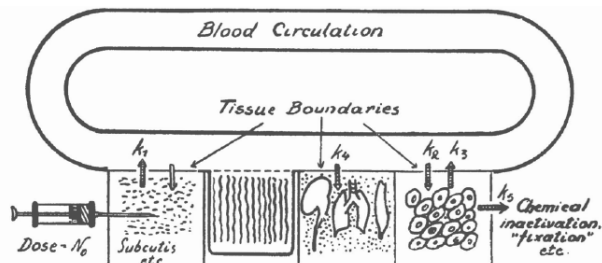
Portal Vein compartment:

$$\frac{d}{dt} C_{pv} = \frac{1}{V_{pv}} \left(Q_{pv} C_{sys} + fa \cdot ka \cdot Fg \cdot Dose \cdot e^{-ka \cdot t} - Q_{pv} C_{pv} \right)$$

- Writing the equations is the easiest!
- Most parameters are measured via experiments.
- Dealing with (uncertain) parameters is harder! - e.g. confronting identifiability and stiffness, estimation.

Physiology Based Pharmacokinetic (PBPK) Models

Models to Describe Tissue Penetration



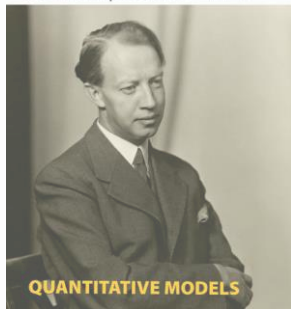
Local	Drug depot	Blood + equivalent Blood vol	Kidney etc. elimination	Tissues	Tissue inactivation
Symbol	D	B	K	T	I
Amount	x	y	u	z	w
Volume	V ₁	V ₂	-	V ₃	-
Concentration	x/V ₁	y/V ₂	-	z/V ₃	-
Perm. coeff	k ₁	-	k ₄	k ₂	-
Velocity constant	out: k ₁ = k ₁ /V ₁ in: neglected	-	not existing	k ₃ = k ₂ /V ₃ k ₂ = k ₂ /V ₂	k ₅
Name of process	Resorption	-	Elimination	Tissue take up - in- output	Inactivation

FIG. 1

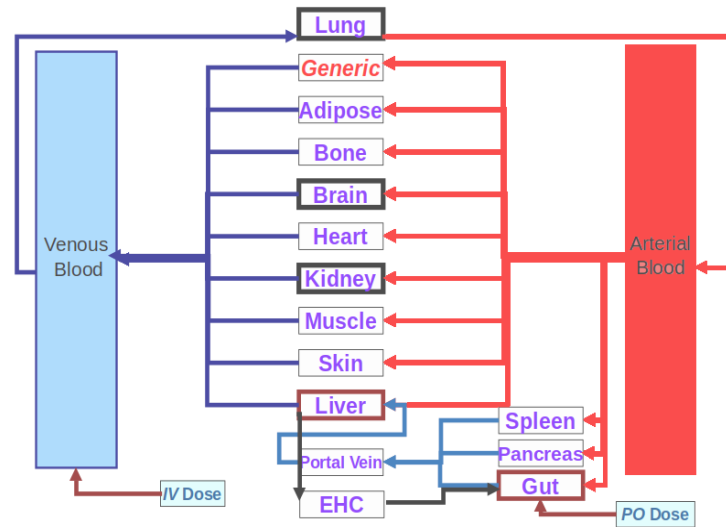
Scheme of the Concept of Drug Distribution used in this paper.

Instead of the injection pictured in the figure, the administration of the drug depot can be made per os, per rectum, by inhalation, etc.

Clinical Pharmacology & Therapeutics



Torsten Teorell (1905–1992)



$$\frac{dC_{Liv}}{dt} = \frac{1}{V_{Liv}} \left[(Q_{Liv} - Q_{PV})C_{ab} + Q_{PV}C_{pv} - \frac{Q_{Liv}C_{Liv}}{P_{Liv,p}/B:P} - \frac{fu}{B:P} \cdot Uptake \cdot \frac{CL_{unt}}{P_{Liv,p}/B:P} \cdot C_{Liv} \right]$$

$$\frac{dC_{vb}}{dt} = \frac{1}{V_{vb}} \left[\left(Q_C - \sum_{Tissues} Q_{Tissue} \right) C_{ab} + \sum_{Tissues} \left(Q_{Tissue} \frac{C_{Tissue}}{P_{Tissue,p}/B:P} \right) - Q_C C_{vb} - \frac{CL_R}{B:P} C_{vb} \right]$$

$$C_{pv} = \frac{1}{Q_{PV}} \left[f_d k_a F_g \cdot Dose \cdot e^{-k_d t} + \left(\frac{(Q_{ST} + Q_{SI} + Q_{LI})}{P_{GI,p}/B:P} C_{GI} + \frac{Q_{Spleen}}{P_{Spleen,p}/B:P} C_{Spleen} + \frac{Q_{Pancreas}}{P_{Pancreas,p}/B:P} C_{Pancreas} \right) + (Q_{PV} - (Q_{ST} + Q_{LI} + Q_{SI}) - Q_{Spleen} - Q_{Pancreas}) C_{ab} \right]$$

Purely Pure Mathematics!

- We can see the point of doing mathematical research in applicable contexts:
 - Applied Mathematics, Modelling, Numerical approaches, Statistics,...
 - But how we justify doing Purely Pure Mathematical Research?

Pure mathematics serves as the foundation for applied sciences.

Just as a solid foundation is crucial for building a structure, pure mathematics provides the theoretical groundwork for various applications.

Where I can start ? Where I can go ?

You have already started your journey.

DO NOT LET ANYTHING STOP THAT!

- Improve your **communication skills**:
- Understand what your **weaknesses, strengths and your interests**.
- Have a clear idea of what you want to do : Not just the area or the name of the job.
- Some of you may want to go directly to a jobs after graduation and some may want to do postgraduate studies.
- How to **talk to non-specialist about your research** or what you have learned?
 - Important when you **face job interviews in private sector**.
- Very few (or one) of you may want to **turn your research project as a business** plan in future – this is quite possible with the technology we have.
 - Example: **Make your project available in Github** or any other online platform.
- There are plenty of freely available/ open source tools to do some freelance type research work.

Where can I start ? Where can I go ?

- See what support you can get from the university, national level organization or private sector to initiate your research project as an online business start-up.
- Even if you cannot find you can use Google Workspace/ WordPress to start your website.
- Or Use LinkedIn – great to connect with industry or academia (for business or academic research).



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Transfer
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University of Ruhuna
Sri Lanka



- It's mainly for innovation, patent for products developed by the university.
- Software solutions based on Mathematical methods ?

Modelling and simulation software platforms conceived as academic research project

Some of these modelling and simulation software platforms used in Drug Development were initiated as spin-outs of university research projects (some are Open Source).



Spin-out of University of Sheffield, UK in 2002. Now a major Modelling and Simulation software platform used by Pharmaceutical industry in drug development.



Laboratory of Applied Pharmacokinetics and Bioinformatics
Optimizing drug therapy for populations and individuals

Open Source

A Success Story from Ruhuna

Sathiska is now an established businessman who started his own IT company.

The screenshot displays the FOSMIS website interface. At the top left is the University of Ruhuna logo. The main header reads "Faculty of Science Management Information System [F O S M I S]". Below this, there is a navigation menu with a highlighted "Download - Permanent number list" button. The central area features a "Sign In" form with fields for "User Name" and "Password", and "Sign In" and "Clear" buttons. To the right, a "History of F O S M I S" section is visible, containing a table of updates and a detailed description of Version 1.0.

University of Ruhuna
Matara-Sri Lanka

For Support
E-Mail: fismis@sci.ruh.ac.lk

Download - Permanent number list

Sign In

User Name

Password

Sign In Clear

Contribution to Development

- Professor WGD Dharmarathna (Advisory) dharm
- Iranga Muthumala (Second Stage Developer, v3.1)

History of F O S M I S

Version 1.0	Developed as a project of the ITRC, Faculty of Science, University of Ruhuna by Sathiska Udayanga and Amal Ranganath with supervision of Dr. Janak R. Wedagedara in 2009. Project duration : March - November 2009.
Version 2.0	Version 1.0 had been updated and tested the system data as a pilot project in part (Mar 2010 to Oct 2010).
Version 3.0	Implementation of FOSMIS for academic staff members, departmental staff. (Oct 2010)
Version 3.1	Completed Attendance management system, upgrading of the code in session management (Jan 2011)

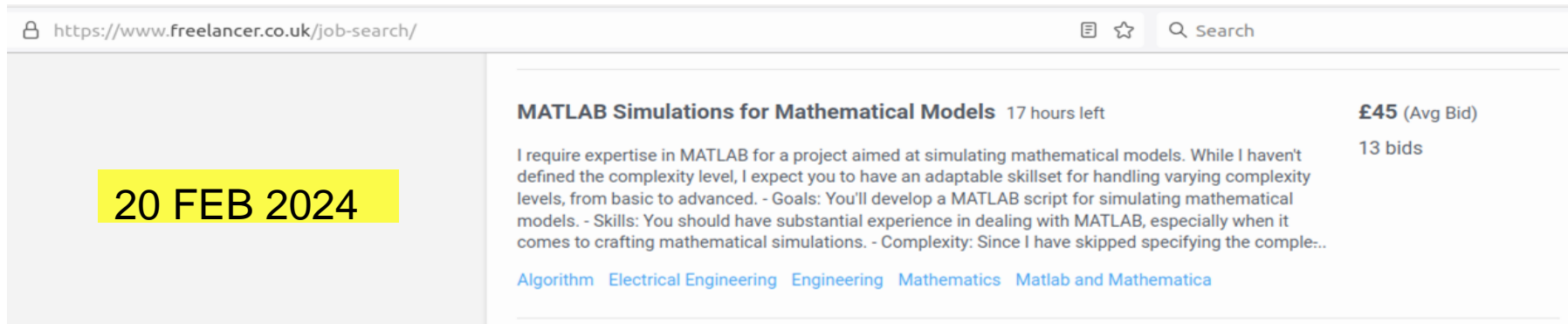
Version 1.0

Developed as a project of the course FSC32P2 offered by ITRC, Faculty of Science, University of Ruhuna by Sathiska Udayanga and Amal Ranganath with supervision of Dr. Janak R. Wedagedara in 2009. Only testing data had been used. Project duration : March - November 2009

© Faculty of Science, University of Ruhuna. [About FOSMIS]

Where I can start ? Where I can go ?

Mathematics Freelance jobs



The screenshot shows a browser window with the URL <https://www.freelancer.co.uk/job-search/>. The main content is a job listing for "MATLAB Simulations for Mathematical Models" with 17 hours left. The average bid is £45 and there are 13 bids. The job description includes requirements for MATLAB expertise, goals of developing a MATLAB script, and skills in dealing with MATLAB. The complexity is noted as being skipped. The job is categorized under Algorithm, Electrical Engineering, Engineering, Mathematics, and Matlab and Mathematica. A yellow box on the left side of the screenshot contains the date "20 FEB 2024".

20 FEB 2024

MATLAB Simulations for Mathematical Models 17 hours left **£45** (Avg Bid)
13 bids

I require expertise in MATLAB for a project aimed at simulating mathematical models. While I haven't defined the complexity level, I expect you to have an adaptable skillset for handling varying complexity levels, from basic to advanced. - Goals: You'll develop a MATLAB script for simulating mathematical models. - Skills: You should have substantial experience in dealing with MATLAB, especially when it comes to crafting mathematical simulations. - Complexity: Since I have skipped specifying the comple..

[Algorithm](#) [Electrical Engineering](#) [Engineering](#) [Mathematics](#) [Matlab and Mathematica](#)

Online Presence and Networking:

LinkedIn: Create and optimize LinkedIn profiles. Connect with professionals in the industry, researchers, and alumni. Engage in relevant discussions and showcase your research projects.

ResearchGate: Share your research on platforms like ResearchGate, connecting with other researchers globally.

Where I can start ? Where I can go ?

Utilize Academic Platforms:

- **Conferences:** Submit abstracts to conferences, even if they are held virtually. Virtual conferences can provide a platform to present their work and network.
- (There are undergraduate research conferences around the world – like this one!!)
- **Academic Journals:** Submit papers to open-access journals. Publications increase visibility and may attract interest from professionals in their field.

Talk to your SUPERVISORS – they are extremely knowledgeable and helpful!!!

Leverage Local Connections:

- Connect with local business chambers or economic development agencies. They may facilitate introductions to industries in the area.
- Alumni Networks: Leverage alumni networks. Alumni may be working in industries or have valuable connections (e.g. Ruhuna University Alumni Association).

Where I can start ? Where I can go ?

Showcase Practical Applications:

- **Case Studies:** Develop case studies showcasing practical applications of your research.
- Share these studies on relevant platforms.

Explore Remote Internship Opportunities:

- **Virtual Internships:** Look for virtual internship opportunities. Some organizations offer remote internships that allow students to contribute to projects remotely.

Milkround.com : <https://www.milkround.com/jobs/internships>

NotGoingtoUni : <https://notgoingtouni.co.uk/>

TargetJobs : <https://targetjobs.co.uk/internships>

Virtual Australia placements : <https://placementyear.org/placements/virtual-australia/>

InternGroup: <https://theinterngroup.com/our-programs/virtual-internships>

... CV CV CV ...

- There are plenty of online job sites where you can prepare a straightforward CV.
- It should have professional and clear format, easy to read and grasp about your skills and training within 30sec to 1 minute:
- Read the following (or any other) guidance:

<https://nationalcareers.service.gov.uk/careers-advice/cv-sections>

- FOR EACH JOB YOU APPLY YOU MUST UPDATE YOUR CV AND THE COVER LETTER.
- START WITH THE JOB ADVERT
- READ THE ESSENTIAL AND GOOD TO HAVE CRITERIA
- READ ABOUT THE COMPANY...
- Get the assistance from ChatGPT or any other language model *BUT do not allow it to destroy your voice!!!* simply ask it to keep your original writing and style as much as possible.

No, I want to do postgraduate studies...

1. Talk to your supervisor or any member of academic staff of the department. See if they are happy to continue to supervise your project towards a postgraduate degree.
2. Or else if you want to do your postgraduate studies in a foreign country the basic requirement is either a four-year degree or a three-year degree with a 1-year master's degree in your speciality.
3. findaphd, jobs.ac.uk, or write directly to members of research groups. This you should plan very well in advance.
4. If you have a First or Upper Second Class Degree with a Four-Year Degree the process is somewhat straightforward. REMEMBER – THERE ARE PLENTY OF OPPORTUNITIES, but you should be able to convince them you are the right person for the job.

Thank you. Any Questions?