AMME2500 Engineering Dynamics 2020:
Assignment 1 (10%)

General Information:

- This assignment is due **Saturday 21st March 11:59pm**
- Late assignments will be deducted 5% (5 marks out of a possible 100) for each day late, starting from midnight on the day after the assignment is due and including weekends. Assignments that are 10 days late or more will receive zero marks.
- Any special consideration requires you to go through the Special Consideration process via Sydney Student.
- Any incidence of academic dishonesty or plagiarism will result in the issue being followed up with the Academic Honesty Coordinator and then onto the University Registrar, and will result in zero marks for this assessment, and may result in automatic failure of this unit of study. For more information on academic honesty, see: https://sydney.edu.au/students/academic-dishonesty-and-plagiarism.html
- This assignment should take the average student 8 hours to complete.

Assignment Objectives:

- This assignment will focus on solutions to problems involving kinematics and kinetics of bodies that may be treated as particles (no rotation).
- You will practice applying techniques using Newton's laws of motion for particles including work, energy, impulse and momentum and working in various coordinate systems to motion problems
- You will use both analytical techniques and computer-based numerical methods to examine these problems

Submission Instructions:

- This assignment involves the submission of a report (containing calculations, embedded MATLAB code/scripts and results) and the separate MATLAB code/scripts themselves.
- You will submit **TWO** files, through two **DIFFERENT** submission portals:
  1) **First file:** A single report file (pdf or word doc format) containing your written solutions to problems, MATLAB/Octave code (cut and pasted into the document in **readable text**, NOT photocopied or as images) and plots from your MATLAB/Octave code. This document should have your name and SID clearly written at the top, and section headings "Question 1", "Question 2", "Question 3" and "Question 4". Within each section, you should provide all of your calculations and answer for that question, and for questions involving a computer-based problem, you should include your MATLAB/Octave code and plots **WITHIN** the section. You will

submit this report using **Turnitin** within Canvas (under the "Assignments" tab) by Saturday 21st March.

2) **Second file:** A zip file containing all MATLAB scripts used for computing solutions to the computer-based problem components. The zip file MUST contain a script file called **"Q1.m"** which contains the solution to Question 1 and produces all of the plots shown in that section of the report. The zip file must be named "Assignment1_**YOURSID**.zip", where "**YOURSID**" is your student ID (NOT your unikey).
   You may include additional files containing MATLAB functions that are called by your script, but the script "Q1.m" must produce all of the results requested.
   You MATLAB script must run without any additional input (must not prompt the tutor to enter any values etc.).
3) The zip file should be emailed to: amme2500engdynamics@gmail.com by Saturday 21st March.

- When presenting solutions to the problem questions:
  - Show all of your calculations and working, clearly illustrated diagrams with relevant variables indicated and working units (use SI units unless otherwise specified)
  - You may submit solutions using either (a) typed mathematical symbols (LaTeX/Microsoft equations etc.) and computer-drawn diagrams or (b) handwritten working and diagrams that will be scanned or photographed for electronic submission.
  - Ensure scanned/photographed working is legible. If the tutor cannot read your work, you will receive **zero** marks for that question.
- When submitting solutions to the coded problems:
  - The code must run **without errors**. Code scripts that produce an error will receive **zero** marks.
  - You code must complete in a **reasonable timeframe**. For this assignment, your code must complete within **120 seconds** when run on the marker's machine. There is no reason that the solution to the problems in this assignment should take longer than this to complete. Code that has not **finished execution within 120 seconds** will receive **zero marks**.
  - You MATLAB scripts should run without any additional input (must not prompt the tutor to enter any values etc.).
  - Comment your code thoroughly (every line for calculations) and perform important steps in the calculation on separate lines of code
  - Graphs and plots must be clearly titled, with correct use of axis labels and legends, units must be specified

Assessment Criteria:

Solutions to problems:

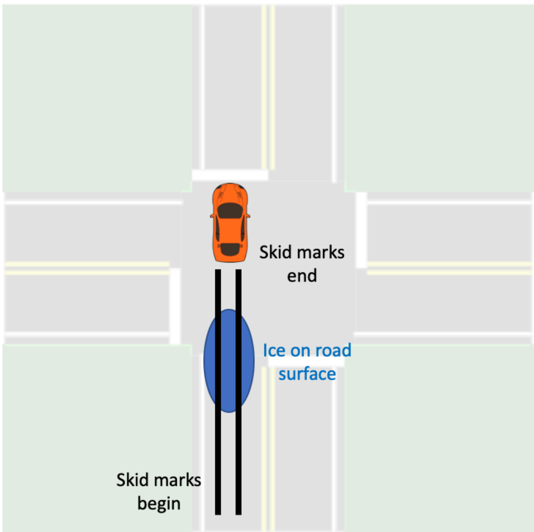
Totally incorrect approach to problem	0%
Correct answer, does not show working or solution is illegible	0%
Partially correct solution or small mistakes made, shows all working, free body diagrams where appropriate	10% to 90%
Correct solution, correct answer, shows all working, free body diagrams where appropriate, clear and legible	100%

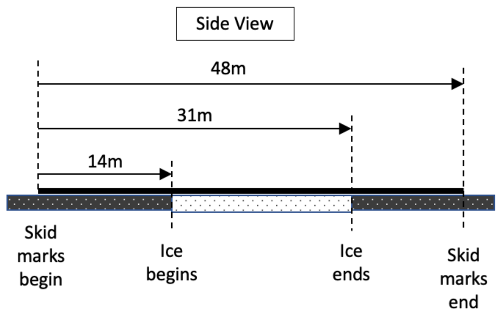
MATLAB Code

Code does not work or raises an error	0%
Totally incorrect approach to problem	0%
Correct answer, but incorrect approach to problem or code is not commented	0%
Partially correct solution or small mistakes made, approach is clear to follow from reading the code and comments, graphs labelled with relevant information	10% to 90%
Correct solution, correct answer, approach is clear to follow from reading the code and comments, graphs labelled with relevant information	100%

Question 1 (35 of 100 marks)

Traffic accident reconstruction is the process of determining variables of interest involved in a collision or other traffic accident (such as the speed at which a car was driving etc.) for the purposes of investigating and determining the causes of a crash. For example, a car equipped with a conventional braking system will often produce skid marks on the road surface during maximal braking: the length of measured skid marks, when combined with information about the frictional forces generated between the locked wheels/tyres of the car and the road surface can be used to estimate the initial speed the car was travelling at when the brakes were applied.





The figure above shows the measured skid marks after a traffic accident for a car that applied its brakes as it approached a road intersection. The road surface over which the skid marks are present has a patch of wet ice present that varies the friction coefficient acting between the car tyres and the road throughout the distance that the car's brakes were applied. An analysis of the road surface results in two different models for the coefficient of kinetic friction (μ) acting between the surface and the car tyres:

Standard road surface (asphalt)	$\mu = 0.7$
Ice	$\mu = 0.12 + 0.07e^{0.06v}$

Where v is the car's current velocity. The road surface is flat and level across the region of the intersection.

i. Using a sideways view, draw a freebody diagram of the forces acting on the car during braking and derive the equation of motion for the acceleration of the car. **(5 Marks)**

ii. Develop a MATLAB function that uses an Euler numerical integration method to solve the equation of motion and produce an approximation for the velocity and displacement of the car (with respect to the position at which the brakes were applied) as a function of time. Your function should be able to model two different scenarios:

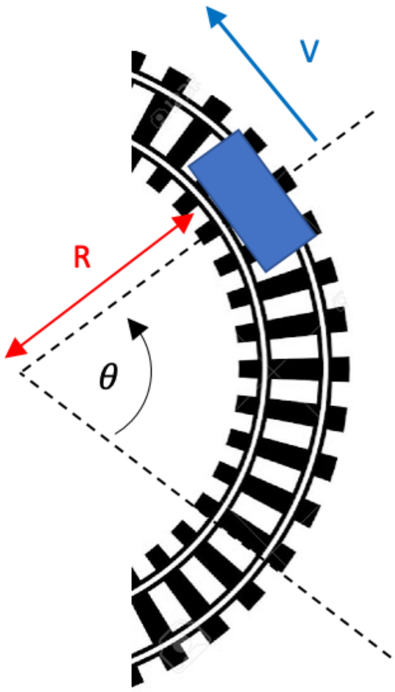
a. Model A: The model ignores the presence of ice at the scene and approximates the kinetic friction coefficient as being a constant value of μ = 0.7.
b. Model B: the model correctly determines the friction coefficient depending on the current surface type (asphalt vs. ice) according to the equations given in the table above.

Your function should take as an input the initial velocity of the car and a second variable that indicates which model will be used. Your function should then output arrays for the time, position/displacement, velocity and friction coefficient for each simulation timestep. Use a value of dt = 0.01s. **(15 Marks)**

iii. Use your developed function in (ii) to produce a plot of the expected stopping distance of the car as a function of initial velocity when the brakes are applied, with values of initial velocity from 20 m/s to 30 m/s. In one figure provide two plots: a curve that indicates the relationship for Model A and a second that indicates the relationship for Model B, each clearly labelled **(10 Marks)**

iv. Use your plot above to identify the estimated initial velocity the car was travelling at when the brakes were applied. Provide estimates for both Model A and Model B. Produce plots of the car's position/displacement and velocity as a function of time, and the coefficient of kinetic friction acting between the car tyres and road as a function of the car's displacement using your estimated initial velocity. Each plot should contain two curves: one for Model A and one for Model B, each clearly labelled. **(5 Marks)**

Question 2 (15 of 100 marks)



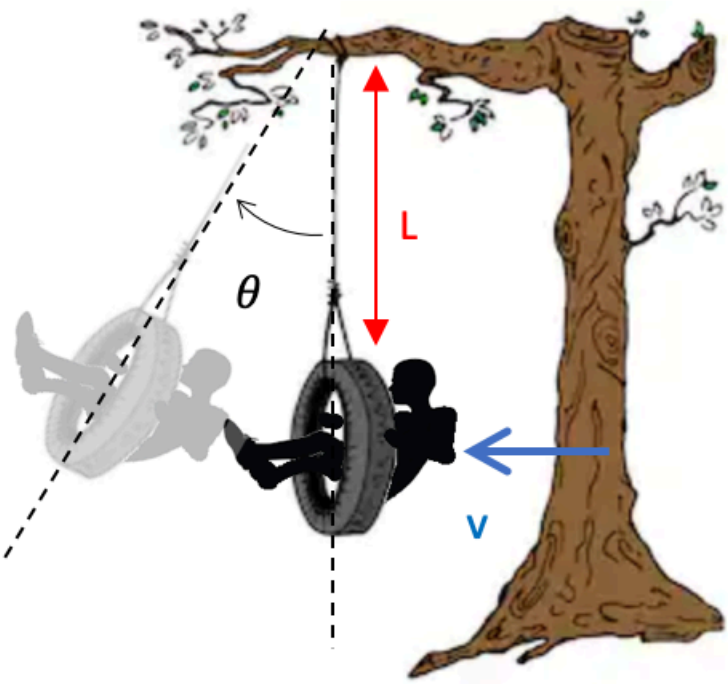
A train shown to the left follows a circular section of track with a radius of 100m. The train starts from rest at θ = 0° and accelerates along the track with a tangential acceleration of $a_t = 0.5e^t \mathrm{m/s^2}$, where t is the time since the train starts moving.

Determine:

i. The magnitude of the velocity and acceleration of the train when t = 3 seconds. **(5 marks)**

ii. The magnitude of the velocity and acceleration of the train when it reaches a point along the track at θ = 30° **(10 marks)**

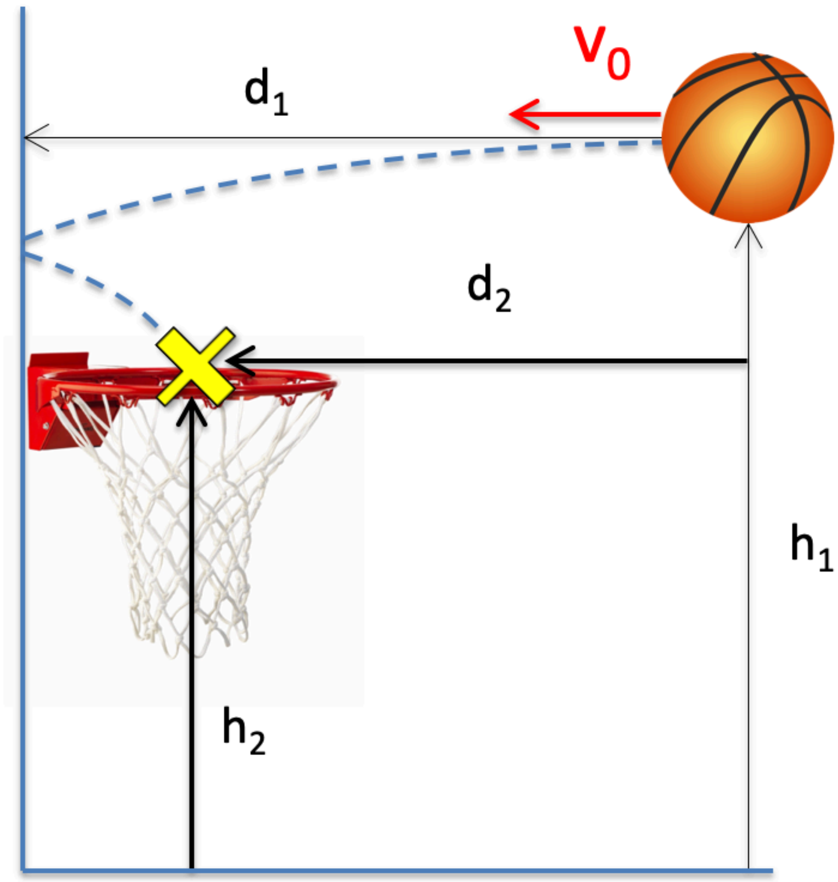
Question 3 (25 of 100 Marks)



A child swinging on a tyre swing mas a mass of 30 kg and is moving at a speed of v = 4 m/s when the swing reaches its lowest point at θ = 0°. Assuming that the size of the child and tyre swing is small with respect to the length of the swing (and can hence be approximated as a particle) and the length of the cord l = 4m, determine:

i. The tension in the cord at θ = 0° **(5 marks)**
ii. The maximum angle θ that the child swings to and momentarily stops **(10 marks)**
iii. The tension in the rope holding the swing at this instant **(10 marks)**

Question 4 (25 Marks)



A basketball is thrown such that it bounces on the backboard and rebounds directly through the centre of the hoop as shown. At the peak height of the ball's trajectory, the ball is travelling with a velocity v_0 in the horizontal direction. The distance between the ball at this point and the backboard is d_1 = 6.0m, and the distance from the ball at this point to the centre of the hoop (in the horizontal direction) is d_2 = 5.5m. The height of the ball at the peak of its trajectory is h_1 = 5.5m and the height of the hoop is h_2 = 3.0m. The coefficient of restitution between the ball and the backboard is e = 0.6.

Determine the velocity v_0 of the ball at the peak height of its trajectory necessary for the ball to achieve the trajectory shown and land directly through the centre of the hoop (neglect any aerodynamic resistance).