UNIVERSITY OF BRITISH COLUMBIA
DEPARTMENT OF MECHANICAL ENGINEERING
FINAL EXAMINATION, December 2018

MECH 463 – Mechanical Vibrations

Duration: 2.5 hours. Answer all 4 questions.

Materials admitted: Non-communicating, non-programmable calculator, personal handwritten notes within one side of one 8.5x11 sheet.

The purpose of this exam is to evaluate your knowledge of the course material. Orderly presentation demonstrates your knowledge most clearly, while disorganized and unprofessional work creates serious doubt. Marks are assigned accordingly. A bonus of up to 3 marks will be given for exemplary presentation.

Write your name on *each* page *during* the examination time.

NAME: _____ SIGNATURE: _____

SECTION: _____ STUDENT NUMBER: _____

Student Conduct During Examinations

1. Each examination candidate must be prepared to produce, upon the request of the invigilator or examiner, his or her UBCcard for identification.
2. Examination candidates are not permitted to ask questions of the examiners or invigilators, except in cases of supposed errors or ambiguities in examination questions, illegible or missing material, or the like.
3. No examination candidate shall be permitted to enter the examination room after the expiration of one-half hour from the scheduled starting time, or to leave during the first half hour of the examination. Should the examination run forty-five (45) minutes or less, no examination candidate shall be permitted to enter the examination room once the examination has begun.
4. Examination candidates must conduct themselves honestly and in accordance with established rules for a given examination, which will be articulated by the examiner or invigilator prior to the examination commencing. Should dishonest behaviour be observed by the examiner(s) or invigilator(s), pleas of accident or forgetfulness shall not be received.
5. Examination candidates suspected of any of the following, or any other similar practices, may be immediately dismissed from the examination by the examiner/invigilator, and may be subject to disciplinary action:
6. i. speaking or communicating with other examination candidates, unless otherwise authorized;
   ii. purposely exposing written papers to the view of other examination candidates or imaging devices;
   iii. purposely viewing the written papers of other examination candidates;
   iv. using or having visible at the place of writing any books, papers or other memory aid devices other than those authorized by the examiner(s); and,
   v. using or operating electronic devices including but not limited to telephones, calculators, computers, or similar devices other than those authorized by the examiner(s) — (electronic devices other than those authorized by the examiner(s) must be completely powered down if present at the place of writing).
7. Examination candidates must not destroy or damage any examination material, must hand in all examination papers, and must not take any examination material from the examination room without permission of the examiner or invigilator.
8. Notwithstanding the above, for any mode of examination that does not fall into the traditional, paper-based method, examination candidates shall adhere to any special rules for conduct as established and articulated by the examiner.
9. Examination candidates must follow any additional examination rules or directions communicated by the examiner(s) or invigilator(s).

CANDIDATES MUST IMMEDIATELY STOP WRITING WHEN THE INVIGILATOR ANNOUNCES THE EXAM IS OVER.

#	Mark	Max.	#	Mark	Max.
1		10	4		10
2		10	Pres.		3
3		10	**Total**		**40+3**

Name _____ Student Number _____

1. (a) Explain in words what is meant by a mode shape. Describe two basic features of a mode shape that are assumed when choosing a suitable trial function for the matrix solution of a vibrating multi-DOF system.

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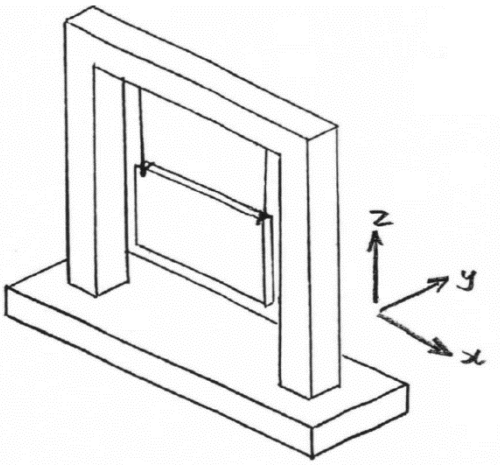
(b) An ornamental sign board hangs at the entrance of a garden. It is rectangular in shape and hangs from two non-stretching cables. Identify the number of degree of freedom and explain why. Use your experience to suggest realistic mode shapes.



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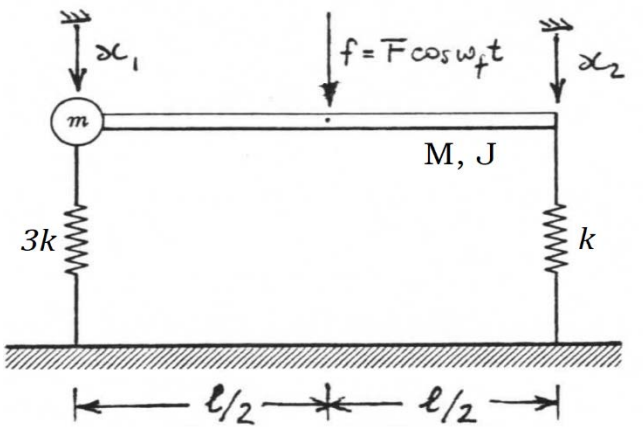
Name _____ Student Number _____

2. A uniform rod of length ℓ is supported by two springs, one of stiffness k and one of stiffness 3k. The rod has mass M = 3m, and polar moment of inertia about its centre J = $M\ell^2/12$. An additional mass m is attached at the end of the rod that is supported by the spring of stiffness 3k. An oscillating vertical force f = F cos $\omega_f t$ is applied at the centre of the rod.



(a) Formulate the equations of motion of the system using Lagrange's Equations.

(b) Determine the response amplitudes due to the oscillating excitation force f.

(c) Comment on and explain your results found in (b).

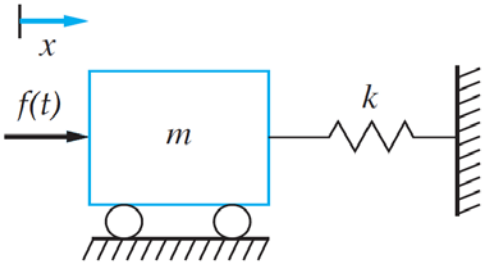
Name _____ Student Number _____

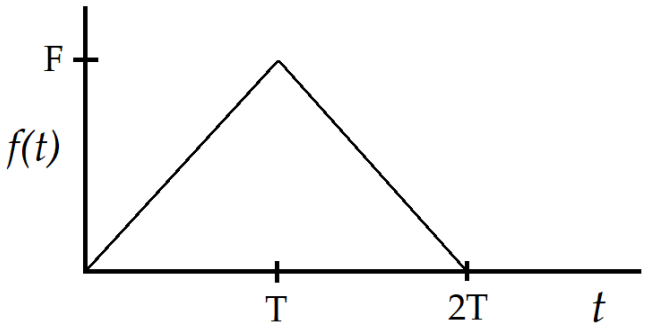
Name _____ Student Number _____

Name _____ Student Number _____

3. (a) A force f = f(t) acts on a simple mass-spring system. Determine the response of the system for zero initial conditions, given f(t) = at.

   (b) Starting from the solution to (a), determine the response of the system to the ramp-pulse excitation shown in the diagram for times t > 2T.





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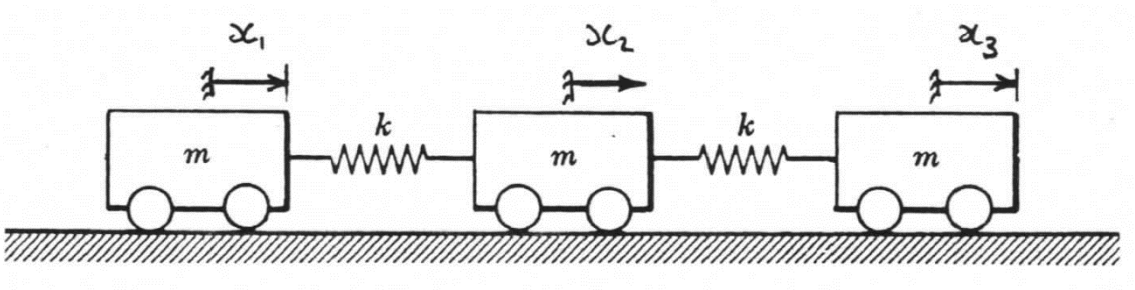
4. Three train cars are on a level track. The cars each have mass m and are connected together by couplings of stiffness k, as shown in the diagram.



(a) Formulate the equations of motion and identify the mass and stiffness matrices.

(b) Based on physical features of the arrangement of train cars, identify two of the three vibration mode shapes of the system by inspection. Explain the reasoning for your identification.

(c) Use mode shape orthogonality to identify the third mode shape.

(d) Use the Rayleigh method to evaluate the natural frequencies corresponding to the three vibration mode shapes identified above.

(e) Give simple physical explanations for the three natural frequencies found.

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Name _____ Student Number _____

Name _____ Student Number _____