IMPERIAL COLLEGE LONDON

MSc ASSESSMENT 2020/21

For internal students of Imperial College London

Taken by students of MSc Applied Computational Science and Engineering

ACSE-2 Assessment – Week 2

09:00 – 11:00 Friday 13 November 2020

This assessment comprises THREE questions. Please answer ALL questions.

The marks to be obtained from answering questions 1 to 3 are as follows:

Question 1: 15 marks
Question 2: 35 marks
Question 3: 50 marks

The assessments are run as open-book assessments, and as such we have worked hard to create a coursework that assesses synthesis of knowledge rather than factual recall. Be aware that access to the internet, notes or other sources of factual information in the time provided may not be too helpful and may well limit your time to successfully synthesise the answers required.

The use of the work of another student, past or present, constitutes plagiarism. Giving your work to another student to use may also constitute an offence. Collusion is a form of plagiarism and will be treated in a similar manner. This is an individual assessment and thus should be completed solely by you.

The College will investigate all instances where an assessment offence is reported or suspected, using plagiarism software, vivas and other tools, and apply appropriate penalties to students. In all assessments, we will analyse performance against performance on the rest of the course and against data from previous years and use an evidence-based approach to maintain a fair and robust assessment.

As with all assessments, the best strategy is to read the question carefully and answer as fully as possible, taking account of the time and number of marks available.

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Please write clearly, annotate any graphs or sketches and explain your answers. Only partial marks will be given for correct answers without an explanation or derivation. Make sure you put a page number on each page of your answer script. GOOD LUCK.

(1) [*15 marks*] Consider the following transformation matrix:

$$\mathbf{T} = \begin{bmatrix} \sqrt{3} & 0 & -\frac{1}{2} \\ 0 & 1 & 0 \\ 1 & 0 & \frac{1}{2}\sqrt{3} \end{bmatrix}$$

(a) Sketch and explain how this transformation modifies an initially orthonormal coordinate system: $\hat{\boldsymbol{e}}_1, \hat{\boldsymbol{e}}_2, \hat{\boldsymbol{e}}_3$.

(b) Is **T** an orthonormal transformation?

(2) [*35 marks*] Consider the motion: $x_1 = \xi_1$; $x_2 = \xi_2 + (\sin \pi t)(\sin \pi\xi_1)$; $x_3 = \xi_3$, where ξ_i is the initial position, x_i the position after displacement, and t is time.

(a) At $t = 0$, a material filament coincides with the straight line that extends from (0; 0; 0) to (1,0,0). Sketch the deformed shape of this filament at $t = 1/2$; $t = 1$ and $t = 3/2$.

(b) Find the velocity and acceleration in material as well as spatial description.

(3) [*50 marks*]

(a) Given the following displacement field u_i as a function of position x_i, in an isotropic linear elastic material:

$u_1 = k(x_1 + x_3^2)$; $u_2 = kx_1x_3$, $u_3 = k(x_1^2 - x_3)$, where constant $k = 10^{-5}$,

find the stress components and comment on the style of deformation.

(b) Next, consider the following equilibrium stress distribution, in the absence of body forces:

$\sigma_{11} = Ax_3$; $\sigma_{12} = \sigma_{21} = Cx_3$; $\sigma_{13} = \sigma_{31} = x_1 + x_2$; $\sigma_{22} = x_1 + x_3$; $\sigma_{23} = \sigma_{32} = Cx_2$; $\sigma_{33} = Cx_1 - Bx_3$,

where A, B and C are constants.

Given that the plane $x_1 + x_3 = 0$ is stress free, determine A, B and C.

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