**The University of Jordan** | **الجامــعة الأردنــيّة**

| **Exam Information بيانات الامتحان** | | | | | |
|---|---|---|---|---|---|
| **الكلية والقسم**<br>**School & Dept.** | **الهندسة/ الهندسة الميكانيكية**<br>**School of Engineering/ Mechanical Engineering** | | | **العام الجامعي**<br>**Academic year** | 2025/2024 |
| **اسم المادة**<br>**Course name** | Strength of Materials 1 | | | **الفصل الدراسي**<br>**Semester** | الأول |
| **رقم المادة**<br>**Course number** | 0904372 | | | **تاريخ الامتحان**<br>**Exam date** | 18 January 2025 |
| **نوع الامتحان**<br>**Exam type** | ☐ أول/ثان<br>1st/2nd | ☐ منتصف الفصل<br>Midterm | ■ نهائي<br>Final | **وقت الامتحان**<br>**Exam time** | 13:00-15:00 |
| **علامة الامتحان**<br>**Exam Mark** | 50 | | | **مدة الامتحان**<br>**Exam duration** | 2 Hours |
| **نوع الأسئلة**<br>**Questions type** | ■ مقالي Open-ended<br>☐ موضوعي Close-ended<br>☐ منوّع Mixed | | | **نوع ورقة الإجابة**<br>**Answer sheet type** | ☐ ورقة إجابة منفصلة<br>Separate answer sheet (bubble sheet)<br>☐ الورقة الأخيرة المرفقة بأوراق الأسئلة<br>Last page attached to the questions papers |
| **الأدوات التي يحتاجها الامتحان**<br>**Exam required tools** | ■ آلة حاسبة Calculator<br>☐ ورق فارغ Blank paper<br>☐ أدوات أخرى وهي: ................ | | | **نوع قلم تدوين الإجابات**<br>**Answering pen type** | ■ قلم رصاص Pencil<br>■ قلم حبر (أزرق/ أسود)<br>Pen (blue/ black) |

| **Student Information بيانات الطالب** | | | | | |
|---|---|---|---|---|---|
| **اسم الطالب باللغة العربية (إجباري)**<br>**Student's name in Arabic*** | | | | | |
| **الرقم الجامعي (إجباري)**<br>**Student's number*** | | **رقم الشعبة**<br>**Section no.** | | **وقت المحاضرة**<br>**Lecture time** | |
| **رقم الجلوس في المحاضرة**<br>**Seat no. in lecture room** | | **رقم الجلوس في الامتحان**<br>**Exam seat no.** | | | |

| **Exam Instructions تعليمات الامتحان** | |
|---|---|
| 1. Read the exam information carefully and adhere to it: question types, answer sheet format, pen type, necessary tools, total exam marks, and exam duration. | 1. قم بقراءة بيانات الامتحان بتمعن والتزم بها: نوع الأســئلة، ونوع ورقة الإجابة، ونوع القلم، والأدوات التي يحتاجها الامتحان، وعلامة الامتحان الكلية، ومدة الامتحان. |
| 2. Ensure that all your question pages are available. | 2. تحقق من توفّر جميع صفحات الأسئلة لديك. |
| 3. Do not place any exam-related materials close to your seat. | 3. يمنع وضع المواد ذات الصلة بالامتحان قريبا من المقعد. |
| 4. Mobile phones are prohibited and must be completely turned off, not in airplane/silent mode. Follow the supervisors' instructions regarding phones. | 4. يحظر استخدام الهواتف النقالة ويتم إغلاقها بشكل تام وليس في وضع الطيران/الصامت، ويجب اتباع تعليمات المراقبين بشأن الهواتف. |
| 5. Use of headphones or any type of smart devices (visual/auditory/sensory) is prohibited. | 5. يحظر اســتخدام ســماعات الرأس أو الأجهزة الذكية من أي نوع (البصرية/ السمعية/ الحسية). |
| 6. Do not use/bring additional papers for the exam; you will be provided with the necessary papers if required during the exam. | 6. يحظر اســتخدام/ إحضــار أوراق إضــافية للامتحان وســيتم تزويدك بالورق الذي تحتاجه إذا تطلب الامتحان ذلك. |

| **Exam Supervisor's Notes ملاحظات مراقب الامتحان** |
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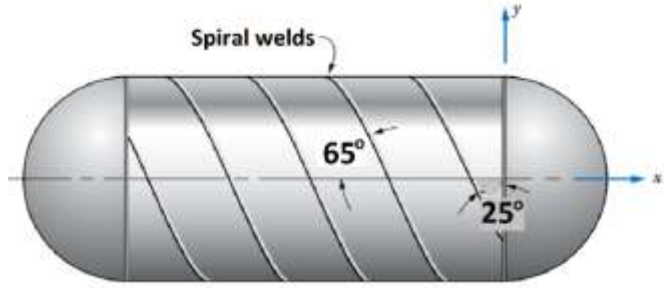
| |

# C is the last two non-zero numbers of your student number

**Q. 1** A tank that is to be made by rolling flat sheets SAE-1040 into the spiral shape shown, where the spiral makes an angle of 65° with the horizontal axis of the tank. The design internal pressure is p=(1000+100×C) kPa. The inside diameter has been specified to be 900 mm to create the desired capacity in the tank.




**A.** Specify a suitable thickness for the steel sheet to provide a design factor of 4 based on yield strength of the steel used ( $\sigma_y = (500 + C)\ MPa.$ )

**B.** For the final design of the tank, determine the stresses on an element aligned with the weld.

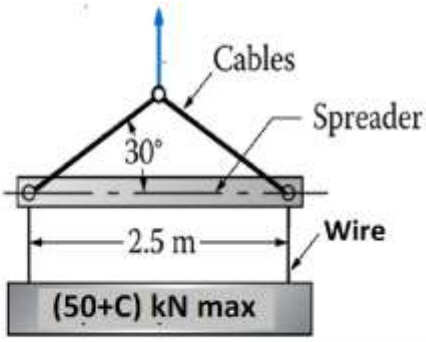
**C.** What is the change in thickness due to the internal pressure?

**Q. 2**

**A)** A sling, is designed to carry a maximum load of (50+C) kN. Up on the Euler buckling critical load design (find the diameter of the solid spreader) the spreader with factor of safety 2.5.

**B)** According to the normal stress in the cables above the spreader, design (find the nominal diameter of the cable) the Cables to provide factor of safety 8 based on ultimate load.

**C)** What is the maximum shear stress in the solid wire if its diameter is



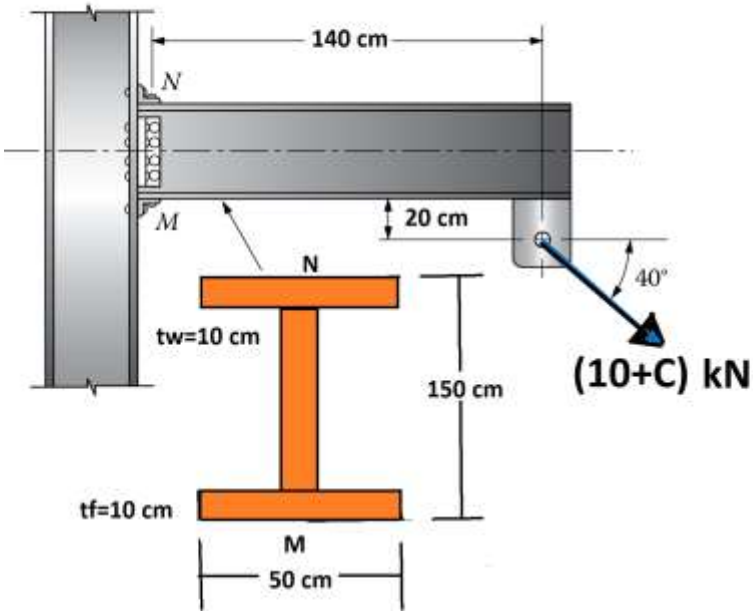

| Nominal diameter (mm) | Approximate weight (N/m) | Effective area ($mm^2$) | Ultimate load (kN) |
|---|---|---|---|
| (12) | (6.1) | (76.7) | (102) |
| (20) | (13.9) | (173) | (231) |
| (25) | (24.4) | (304) | (406) |
| (32) | (38.5) | (481) | (641) |
| (38) | (55.9) | (697) | (930) |
| (44) | (76.4) | (948) | (1260) |
| (50) | (99.8) | (1230) | (1650) |

**Q. 3** The beam shown carries a (C+ 10) kN load attached to a bracket below the beam.

**A)** Compute the stresses at points M and N, where it is attached to the column.

**B)** Find the principle stresses and the maximum shear stress at one of them

**C)** Assuming that the bracket is rigid, find the displacement of the point of application of the load.



**Q. 4** The load shown is being carried by an extruded aluminum (E=(C+10) GPa) beam having the cross sectional area shown.

**a)** Draw the shear force–Bending Moment diagrams.

**b)** Find the location of neutral axis as well as the moment of area of the cross section

**c)** Compute the deflection of the beam for each load separately.

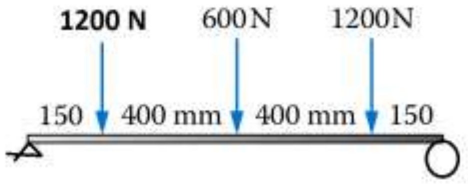
**d)** Use the superposition principle to find the total deflection at the mid-span

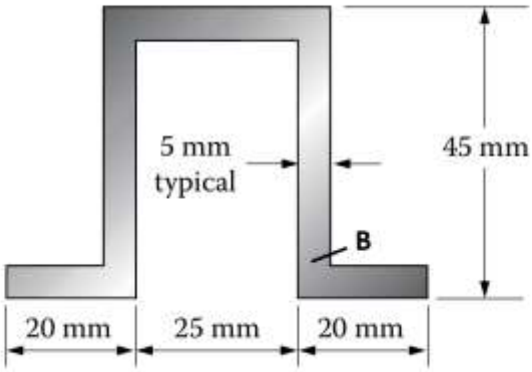
**e)** Use the superposition principle to find the total slope at the roller.

**f)** Find the maximum shear stress in the beam

**g)** Find the maximum normal stress in the beam

**h)** Find the shear stress in the web at point B




cross section

**Formula sheet, 2025**

**Prof. Ibrahim Abu-Alshaikh, JU, Mechanical Engineering Department**

$$FS=\frac{\sigma_y}{\sigma_{allow}} \text{ and } FS=\frac{\tau_y}{\tau_{allow}};\quad FS=\frac{\sigma_u}{\sigma_{allow}} \text{ and } FS=\frac{\tau_u}{\tau_{allow}};\quad \sigma=E\varepsilon;\ \tau=G\gamma$$

$$\sigma=\frac{F}{A};\quad \tau_{aver}=\frac{F}{A};\quad \delta=\sum_{i=1}^{n}\frac{P_iL_i}{E_iA_i};\quad \delta=\frac{PL}{EA};\quad \delta=\int_0^L\frac{P(x)}{EA(x)}dx;\quad \upsilon=\frac{\varepsilon_{lateral}}{\varepsilon_{longitudinal}}$$

Power & Torsion:

$$\phi=\frac{TL}{GI_p};\quad I_p\left(\text{Solid Shaft of diam.} = d\right)=\frac{\pi d^4}{32};\quad I_p\left(\text{Hollow Shaft}\begin{cases}d_o \text{ :outer diam.}\\ d_i \text{ :inner diam.}\end{cases}\right)=\frac{\pi\left(d_o^4-d_i^4\right)}{32}$$

$$\tau_{\max}=\frac{T(d/2)}{I_p};\quad \tau=\frac{T\rho}{I_p}\left(\text{where } 0\le\rho\le r=\frac{d}{2}\right);\quad G=\frac{E}{2(1+\upsilon)};\quad P(\text{power})=\omega T;\ \omega=2\pi f$$

$$\frac{dV}{dx}=-q;\quad \frac{dM}{dx}=V \quad\Leftrightarrow\quad \begin{cases}\int_A^B dV = V_A-V_B=-\int_A^B q\,dx=-\left(\text{Area of the loading diagram bt. A and B}\right)\\ \int_A^B dM = M_A-M_B=\int_A^B V\,dx=\left(\text{Area of the shear-force diagram bt. A and B}\right)\end{cases}$$

$$\kappa(\text{curvature})=\frac{1}{\rho}=\frac{d\theta}{ds}=\frac{-\varepsilon_x}{y};\quad \sigma_x=\frac{-M_z y}{I_z};\quad \tau=\frac{VQ}{Ib};\quad Q=\int y\,\mathrm{dA};\quad Q_{Circle\ at\ NA}=d^3/12$$

Mohr's Circle, Stress Trans. & Princ. Stresses:

$$\sigma_{x1},\sigma_{y1}=\sigma_{aver}\pm\sigma_{diff}\cos(2\theta)\pm\tau_{xy}\sin(2\theta);\quad \sigma_{aver}=\frac{\sigma_x+\sigma_y}{2};\quad \sigma_{diff}=\frac{\sigma_x-\sigma_y}{2}$$

$$\tau_{x1y1}=-\sigma_{diff}\sin(2\theta)+\tau_{xy}\cos(2\theta);\quad \sigma_{1,2}=\sigma_{aver}\pm R;\quad R=\sqrt{\left(\sigma_{diff}\right)^2+\left(\tau_{xy}\right)^2}$$

**Hooke's law for plane stress & vessels:**

$$\begin{cases}\varepsilon_x=\frac{1}{E}\left(\sigma_x-\upsilon\sigma_y\right)\\ \varepsilon_y=\frac{1}{E}\left(\sigma_y-\upsilon\sigma_x\right)\\ \varepsilon_z=\frac{-\upsilon}{E}\left(\sigma_y+\sigma_x\right)\end{cases}\quad \begin{cases}\sigma_x=\frac{E}{1-\upsilon^2}\left(\varepsilon_x+\upsilon\varepsilon_y\right)\\ \sigma_y=\frac{E}{1-\upsilon^2}\left(\varepsilon_y+\upsilon\varepsilon_x\right)\\ e(\text{dilatation})=\frac{\Delta V}{V}=\varepsilon_x+\varepsilon_y+\varepsilon_z\end{cases}$$

Thin-walled spherical vessel: $\sigma=\frac{pr}{2t}$

Thin-walled cylindrical vessel: $\begin{cases}\sigma_{axial}=\frac{pr}{2t}\\ \sigma_{hoop}=\frac{pr}{t}\end{cases}$

**Deflection & Buckling**

$$\begin{cases}EI\frac{d^2v}{dx^2}=M\\ \theta(slope)=\frac{dv}{dx}\end{cases}\quad \begin{cases}\text{Pinned-Pinned Column } K=1; & \text{Fixed-Free Column } K=2\\ \text{Fixed-Fixed Column } K=0.5; & \text{Fixed-Pinned Column } K=0.699\end{cases}\quad\Leftrightarrow\quad P_{cr}=\frac{\pi^2 EI}{(K\,L)^2}$$