The University of Jordan | **الجامعة الأردنيّة**

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

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

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 اســـتخدام ســـماعات 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/ إحضـــار أوراق إضـــافية للامتحان وســيتم تزويدك بالورق الذي تحتاجه إذا تطلب الامتحان ذلك.

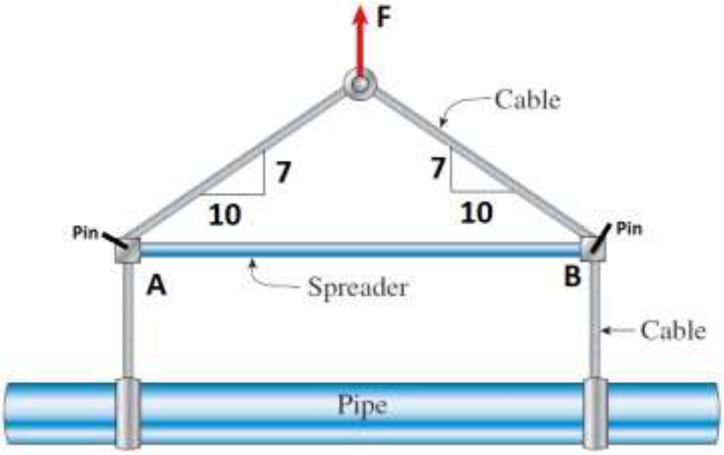
Exam Supervisor's Notes ملاحظات مراقب الامتحان
SN=4

The hoisting arrangement for lifting a large pipe is shown in the figure. The spreader is a steel tubular section with outer diameter (**10×SN**) mm and inner diameter (**10×SN-10**) mm, its length is 2.8 m and its modulus of elasticity is 180 GPa.

Q1. Based upon a factor of safety of 2.25 with respect to Euler buckling of the spreader, what is the maximum weight of pipe that can be lifted? (Assume pinned conditions at the ends of the spreader.)

(a)264460.78 (b)76477.535 (c)51600.22

(d)25538.652 (e)1153.51 (*f*)4498.678



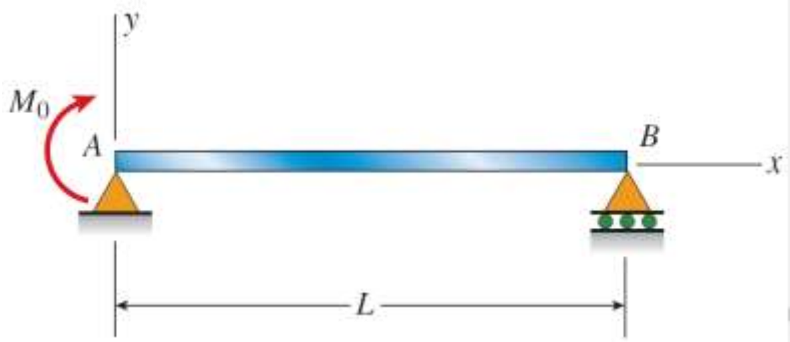
A simple beam *AB* of length L= 2m is loaded by a couple M_0 = 600 N.m at the left-hand support with flexural rigidity EI= **123456×SN** (N.m^2).

Q2. The deflection (mm) at the mid-span (x=L/2) of the beam is:

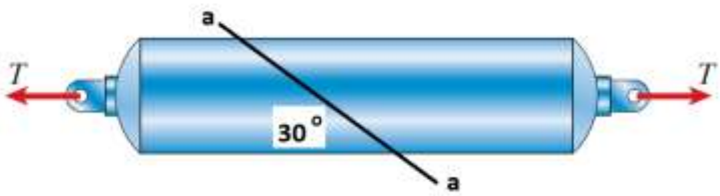
(a)-1.215 (b)-0.17357 (c)-0.6075 (d)-0.2430 (e)-0.405 (*f*)-0.729

Q3. The slope (rad) at the right end of the beam (at B):

(a)0.000231 (b) 0.00054 (c)0.001157 (d)0.00405 (e)0.0027 (*f*)0.000324



A cylindrical tank having diameter d=200mm is subjected to internal gas pressure p = **SN** (MPa) and an external tensile load T = 4.5 kN. Assuming that the cross sectional area of the cylindrical vessel is $\left(A = t\,\pi d\right)$



Q4. The minimum thickness *t (mm)* of the wall of the tank if the allowable normal stress at the outer boundary is 80 MPa.

(a)2.5 (b)3.75 (c)7.5 (d)5 (e)6.25 (f)8.75

Q5. The minimum thickness *t (mm)* of the wall of the tank if the in-plane allowable shear stress $\left(\tau_{\max} = \left|\frac{\sigma_1 - \sigma_2}{2}\right|\right)$ at the outer boundary is 20 MPa.

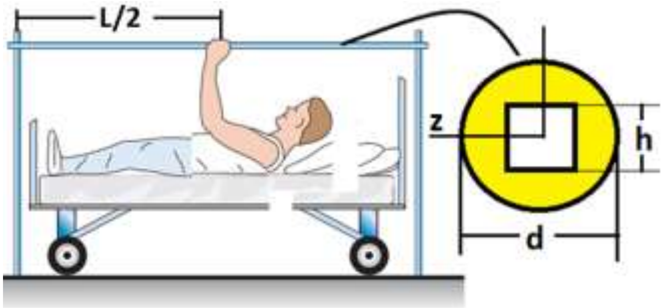
(a)8.571 (b)17.5 (c)15 (d)3.571 (e)6.071 (f)12.5

Q6. If the thickness of the wall is 10 mm, find the state of stresses $\left(\sigma_a,\ \tau_a\right)$ along the inclined plane a-a

(a)43.929,10.515 (b)35.179,8.350 (c)61.429,14.845

(d)17.679,4.020 (e)52.679,12.680 (f)26.429,6.185

A bar in a hospital room provides a means for patients to exercise while in bed. The bar is 2.2 m long and has a circular cross section with a square hole as shown, where d = **20×SN** mm. The design load is 1.2 kN applied at the midpoint of the bar.



Q7. If h=30 mm what is the second moment of inertia (mm^4) of the cross- section about z-axis.

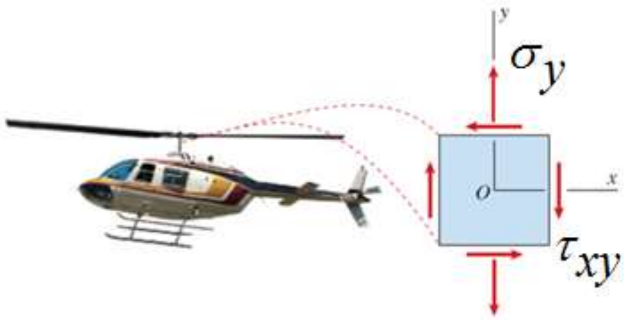
(a)5.686×10^5 (b)1.879×10^7 (c)4.841×10^6

(d)58163.706 (e)3.210×10^7 (f)1.943×10^6

Q8. If the allowable bending stress is 200 MPa, determine the minimum value of h (mm) (Assume that the ends of the bar are simply supported and its weight is negligible)

(a)68.905 (b)139.882 (c)50.39 (d)29.088 (e)86.86 (f)122.272

It is known that the stresses on the rotor shaft of a helicopter are: normal stress $\sigma_y = 10 \times SN$ MPa and shear stress $\tau_{xy} = -5 \times SN$ MPa. Using Mohr's circle, determine the following.



Q9. The largest principle stress (MPa) on the rotor is:

(a)56.56 (b)49.49 (c)63.63 (d)21.21 (e)70.70 (f)35.35

Q10. The maximum shear (MPa) stress in the shaft is:

(a)108.63 (b)60.35 (c)120.71 (d)36.21 (e)96.56 (f)84.49

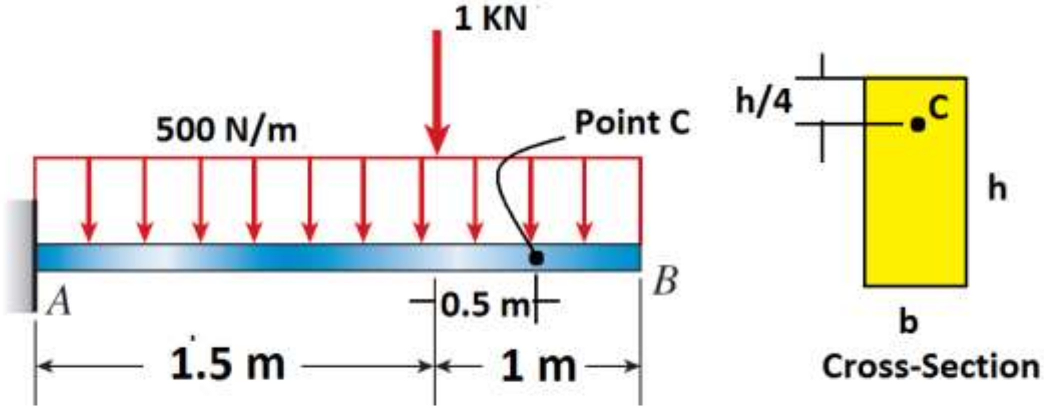
For the loaded cantilever beam shown if h =**12×SN** mm, and b =**2×SN** mm

Q11. The normal stress at point C (MPa) is

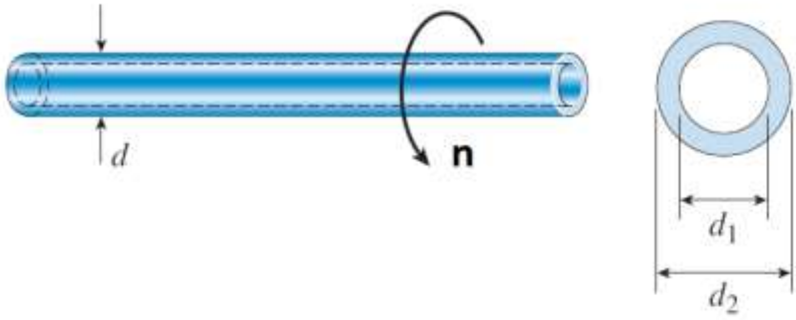
(a)2.39 (b)24.11 (c)1.898 (d)1.271 (e)10.17 (*f*)5.208

Q12. The shear stress at point C in MPa is

(a)0.1831 (b)0.732 (c)0.468 (d)0.325 (e)0.239 (*f*)1.302



A drive shaft is running at n=**400×SN** rpm and the allowable shear stress in the shaft is $\tau_{allow} = 30\ \text{MPa}$.



Q13. If the outer diameter of the shaft is 60 mm and inner diameter 40 mm, the maximum power that can be transmitted by the hollow shaft is approximately (kW):

(a)42.768 (b)342.146 (c)85.536 (d)213.84 (e)299.378 (f)128.30

Q14. If this shaft is replaced by a solid shaft that have the same material and weight, the maximum power that can be transmitted by the solid shaft is approximately (kW):

(a)110.34 (b)66.20 (c)176.55 (d)44.138 (e)154.483 (f)22.069

Q15. Discuss the results of Q13 and Q14

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

$$\begin{cases}\phi=\dfrac{TL}{GI_p};\quad I_p\left(\text{Solid Shaft of diam.} = \text{d}\right)=\dfrac{\pi d^4}{32};\quad I_p\left(\text{Hollow Shaft}\begin{cases}d_o \text{ :outer diam.}\\ d_i \text{ :inner diam.}\end{cases}\right)=\dfrac{\pi\left(d_o^4-d_i^4\right)}{32}\\ \tau_{\max}=\dfrac{T(d/2)}{I_p};\quad \tau=\dfrac{T\rho}{I_p}\left(\text{where } 0\le\rho\le r=\frac{d}{2}\right);\quad G=\dfrac{E}{2(1+\upsilon)};\quad P(\text{power})=\omega T;\ \omega=2\pi f\end{cases}$$

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

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

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

$$\begin{cases}\sigma_{x1},\sigma_{y1}=\sigma_{aver}\pm\sigma_{diff}\cos(2\theta)\pm\tau_{xy}\sin(2\theta);\quad \sigma_{aver}=\dfrac{\sigma_x+\sigma_y}{2};\quad \sigma_{diff}=\dfrac{\sigma_x-\sigma_y}{2}\\ \tau_{x1y1}=-\sigma_{diff}\sin(2\theta)+\tau_{xy}\cos(2\theta);\quad \sigma_{1,2}=\sigma_{aver}\pm R;\quad R=\sqrt{\left(\sigma_{diff}\right)^2+\left(\tau_{xy}\right)^2}\end{cases}$$

Hooke's law for plane stress & vessels:

$$\begin{cases}\varepsilon_x=\dfrac{1}{E}\left(\sigma_x-\upsilon\sigma_y\right)\\ \varepsilon_y=\dfrac{1}{E}\left(\sigma_y-\upsilon\sigma_x\right)\\ \varepsilon_z=\dfrac{-\upsilon}{E}\left(\sigma_y+\sigma_x\right)\end{cases}\begin{cases}\sigma_x=\dfrac{E}{1-\upsilon^2}\left(\varepsilon_x+\upsilon\varepsilon_y\right)\\ \sigma_y=\dfrac{E}{1-\upsilon^2}\left(\varepsilon_y+\upsilon\varepsilon_x\right)\\ e(\text{dilatation})=\dfrac{\Delta V}{V}=\varepsilon_x+\varepsilon_y+\varepsilon_z\end{cases}\begin{cases}\text{Thin-walled spherical vessel: } \sigma=\dfrac{pr}{2t}\\ \text{Thin-walled cylindrical vessel: }\begin{cases}\sigma_{axial}=\dfrac{pr}{2t}\\ \sigma_{hoop}=\dfrac{pr}{t}\end{cases}\end{cases}$$

Deflection & Buckling

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