The University of Jordan الجامعة الاردنية

Paper-based :Form Questions Cover Sheet	Policy Number	SUJ-02-01-04A
	Issue Number and Date	2/3/24/2022/2963 5/12/2022
	Number and Date of Revision or Modification	
	Deans Council Approval Decision Number	3/ 4/24/2023
	The Date of the Deans Council Approval Decision	23/1/2023
	Number of Pages Including this Page	09

School	Engineering			Department	Mechanical
Course Name	Strength of Materials			Course No.	0904372
Academic Year	2023-2024	Semester	Fall	Exam Type	Final Exam
Exam Date	12 June 2024			Exam Time	12:00-14:00

اسم الطالب(بالعربي):	الرقم الجامعي:

اسم المدرس: ا.ابرههيم ابوالشيخ	رقم الشعبة: 2&1	وقت المحاضرات: Sun., Tus., Thu. 11:30-12:30, Mon., Wed. 11:30-13:00

Important Instructions

- This is an (closed) book exam.
- Cell phone use is prohibited for any purpose: Your cell phone must be turned off and placed off of the desk. Cell phones may not be accessed during the exam. Failure to comply may be treated as a violation of the Honor Code.
- Headphones of any kind are not permitted.
- This exam is (**120**) minutes long.
- Make sure that you have (9) pages including this page.
- This exam has (17) questions. Read each question carefully before answering. **Show** your detailed solution. Answers without detailed solution **will NOT be weighted**.
- Calculators can be used but can (*not*) be shared.
- When you finish, you must:
  - Check that you have written your information in the spaces provided.
  - Give the exam package (all papers) to the proctor before you leave.

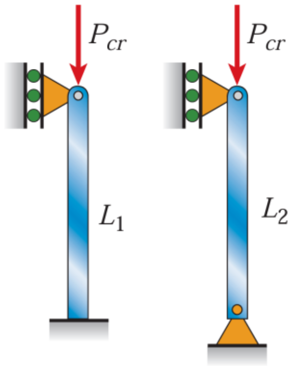
For Teacher's Use Only

No.	ILO	SO	DL	Mark	Weight
1,2,3	5	2	1		9
4,5,6,7	1, 3	1, 2	2		12
8,9	3, 5	2	2		6
10, 11	3, 4	2	1		6
12,13,14	3	2	2		9
15,16,17	3, 1	1, 2	2		9
Total					51

***KPI**: Key Performance Indicator, **ILO**: Intended Learning Outcomes, **SO**: Student Outcomes, **DL**: Difficulty Level (1. Easy, 2. Average, 3. Hard, 4. Very Hard)*

β is the last odd number in your Student Number.

Q1: Two pipe columns are required to have the same Euler buckling load. Column 1 is pinned-pinned, has flexural rigidity EI, and height L_1; Column 2 is pinned-fixed, has flexural rigidity $(4EI/\beta)$, and height L_2. The ratio (L_2/L_1) is:



A)1.53 B)1.28 C)0.47 D)2.86

E)1.60 F)1.65 G)0.95 H)1.08

Q2: A thin wall spherical tank of diameter 0.75β m has internal pressure of 10 MPa. The modulus of elasticity is 210 GPa, Poisson's ratio is 0.28, and maximum normal strain is 0.001220. The minimum permissible thickness of the tank is:

A) 15.81 mm B)26.35 C)47.42 D)15.81

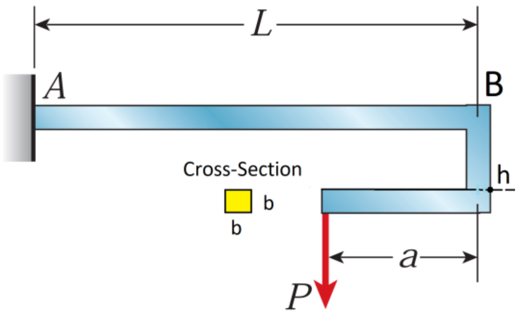
E)3.77 F)5.27 G)36.88 H)52.69

Q3: A pinned-end copper column (E=110 GPa, L=4.6 m) is constructed of circular tubing with outside diameter $d=(60+\beta)$ mm. The strut must resist an axial load P= 16 kN with a factor of safety 2.0 with respect to the critical buckling load. The required thickness t of the tube is:

A)6.410 mm B)7.382 C)17.059 D)8.687

E)14.162 F)10.610 G)5.273 H)6.010

A steel square bracket with EI= 40200000 N.m^2, L=5.5 m, and a =2 m is subjected to load $P=(10+\beta)$ kN at D.



Q4: The maximum deflection at B is:

A)-7.274 mm B)-11.914 C)-9.406 D)-12.357

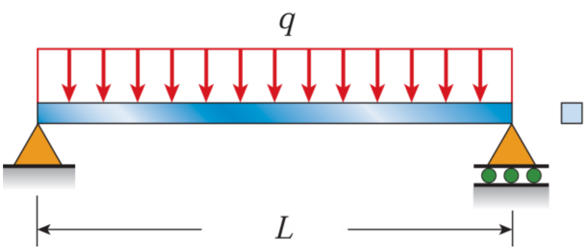
E)-10.660 F)-5.444 G)-6.898 H)-8.152

Q5: The normal stress at point h if $b=(250+\beta)$ mm is:

A)-8.17 MPs. B)-13.57 C)-18.43 D)-11.76

E)-12.84 F)-15.42 G)-10.62 H)-9.43

An aluminum beam (E=75 GPa, L=2.5 m) has a square cross section and subjected to uniform load $q=(1.5+\beta)$ kN/m. The allowable bending stress is 60 MPa.



Q6: The cross-sectional dimension is:

A)93.611 mm B)79.781 C)108.83 D)87.24

E)90.611 F)58.019 G)70.578 H)65.58

Q7: The slope at the left support is:

A)-0.01424 rad B)-0.0153 C)-0.01671 D)-0.0189

E)-0.01225 F)-0.0189 G)-0.0272 H)-0.0230

A thin cylindrical tank has inner diameter is d=2 m and wall thickness $t=(25+\beta)$ mm subjected to both internal pressure P and compressive force F=750 kN. If the allowable normal stress is 110 MPa and allowable shear stress is 60 MPa.

Q8: The maximum allowable internal pressure P_{max} is:

A)2.65 MPa B)3.52 C)2.50 D)2.86

E)3.74 F)2.95 G)3.080 H)3.300

Q9: The maximum shear stress at the inner boundary in the out of plane direction is:

A)6.00 MPa B)6.96 C)7.92 D)8.98

E)6.48 F)7.44 G)8.25 H)9.34

Q10: A motor drives a shaft with diameter $d=(40+\beta)$ mm at frequency f=5.25 Hz and delivers P=25 kW of power. The maximum shear stress in the shaft is:

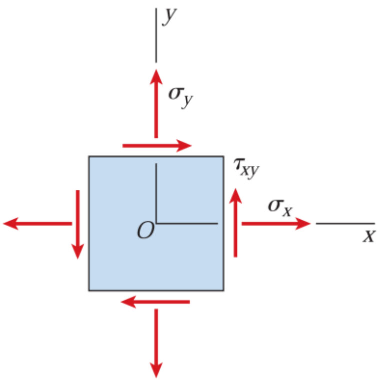
A)84.45 MPa B)65.32 C)48.55 D)32.81

E)37.18 F)59.45 G)42.36 H)56.00

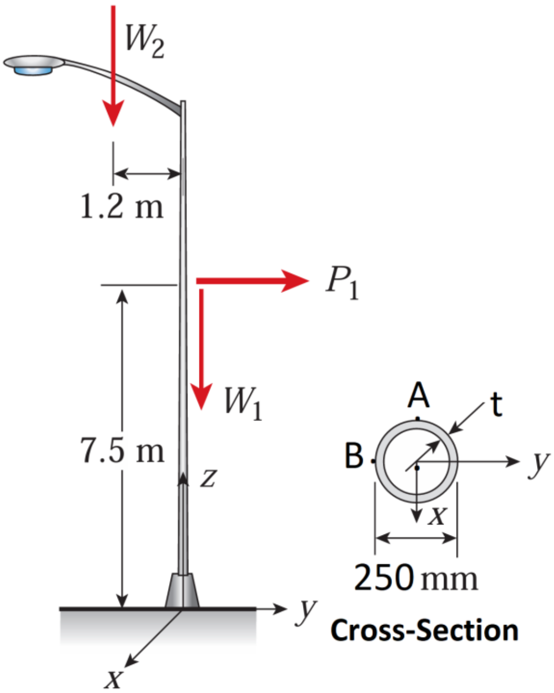
Q11: A drive shaft resists torsional shear stress of 40 MPa and axial compressive stress in x-direction is -70 MPa. One principal normal stress is known as $(30+\beta)$ MPa (tensile). The stress in y-direction is:

A)20.90 MPa B)23.18 C)24.32 D)15.16

E)22.05 F)19.76 G)25.45 H)17.46



An aluminum light pole weighs W_1= 5000 N, supports W_2=800 N, and a wind force of P_1=2000 N as shown. The pole cross section at the base has outside diameter 250 mm and thickness $t=(30+\beta)$ mm.



Q12: The normal stress at the base at point A is:

A)-0.2376 MPa B)-0.2198 C)-0.2453 D)-0.21545

E)-0.22435 F)-0.2578 G)-0.2343 H)-0.2719

Q13: The normal stress at the base at point B is:

A)12.696 MPa B)11.2654 C)11.5711 D)12.2709

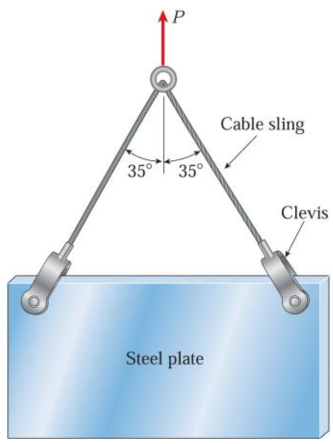
E)11.4221 F)11.8986 G)11.2818 H) 13.1838

Q14: The shear stress at the base at point B is:

A)0.1663 MPa B)0.1480 C)0.1751 D)0.15840

E) 0.1851 F)0.1563 G)0.1449 H)0.151318

A steel plate weighing $(20+\beta)$ kN is hoisted by a cable sling that has a clevis at each end. The pins through the clevises are 25 mm in diameter. Each half of the cable is at an angle of 35° to the vertical.



Q15: Normal stress in the cable of nominal diameter is 32 mm is:

A)34.26 MPs B)22.87 C)36.80 D)41.62

E)29.19 F)15.92 G)26.65 H)31.72

Q16: The average shear stress in each pin is:

A)11.38 MPs B)13.056 C)14.300 D)16.165

E)14.922 F)18.030 G)15.543 H)6.787

Q17: Neglecting the weight of the cable, the fracture load that can be carried by the hoist is:

A)1.05 MN B)2.05 C)3.05 D)4.05

E)5.05 F)6.05 G)7.05 H)8.05

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)

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

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

Power & Torsion:

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

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

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

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

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

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

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

Hooke's law for plane stress & vessels:

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

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

Deflection & Buckling

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