دانشگاه کردستان
University of Kurdistan

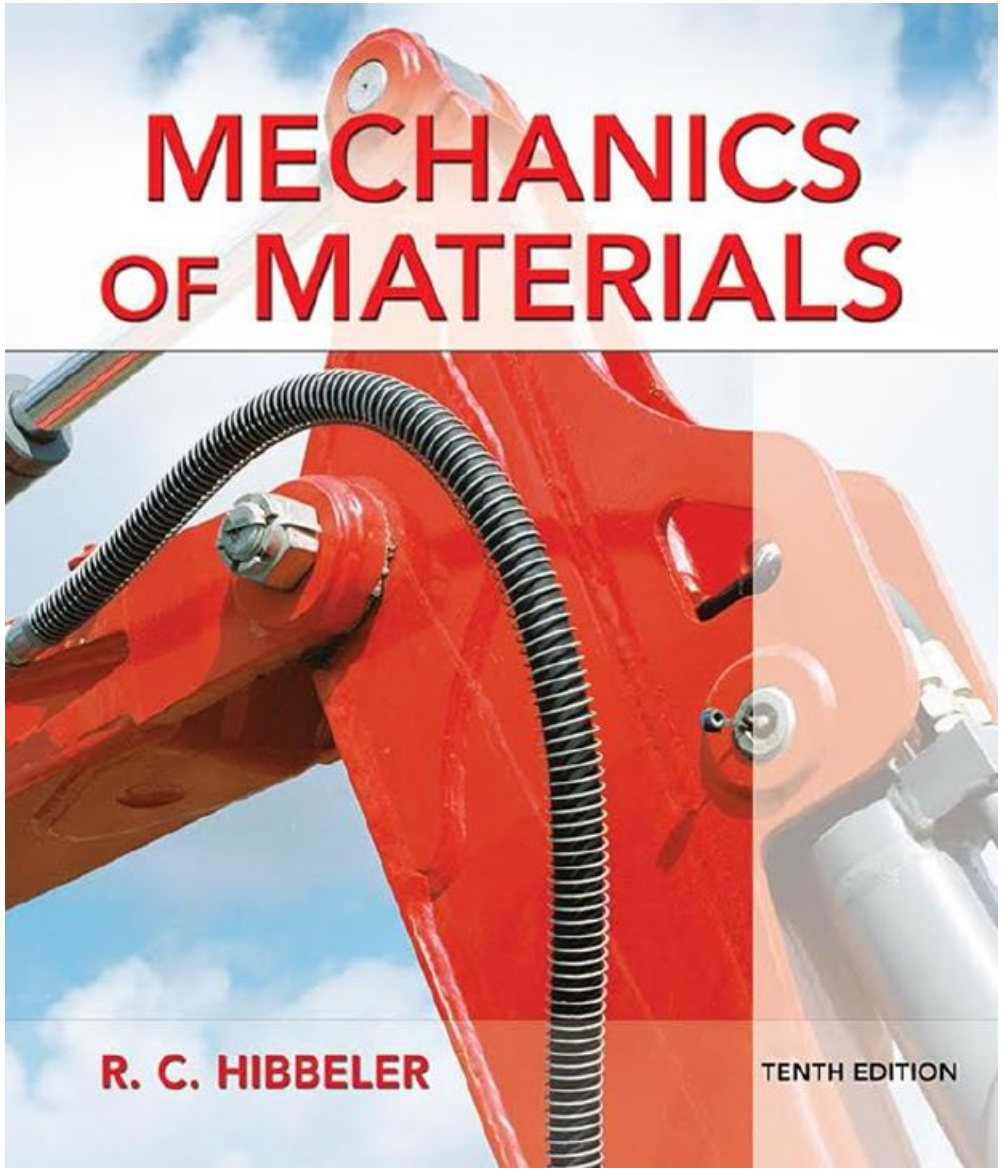
MECHANICS OF MATERIALS

By: Arman Mamazizi

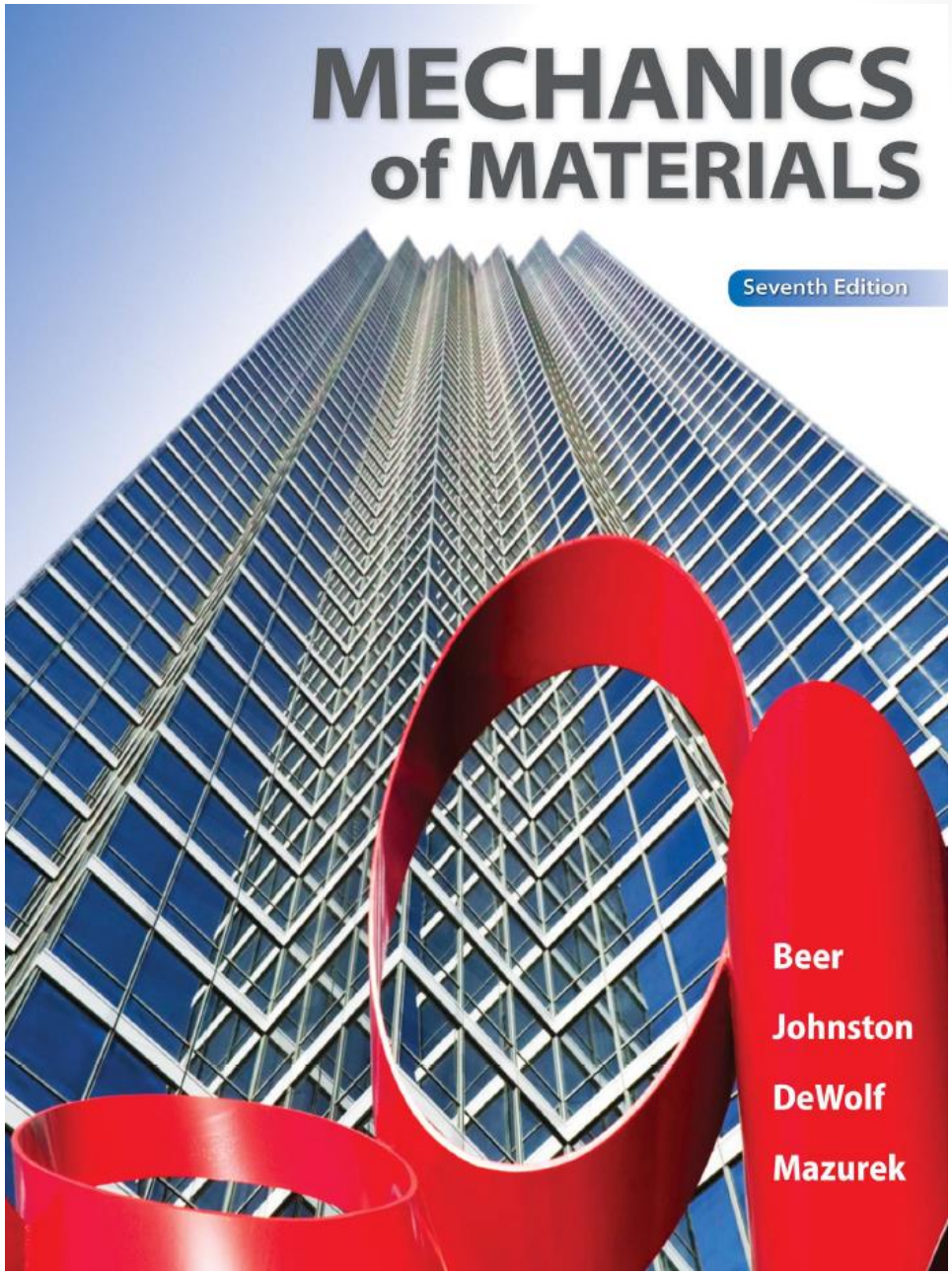
Assistant Prof. of Structural Engineering

Mamazizi.arman@gmail.com

References:



References:


MECHANICS
of MATERIALS
Seventh Edition
Beer
Johnston
DeWolf
Mazurek

Contents

نحوه ارزشیابی

کوییز و فعالیت کلاسی و تمرینات

۴ نمره

میانترم اول ۳ نمره

(یک شنبه ۲۷ فروردین)

میانترم دوم ۳ نمره

(یک شنبه ۳۱ اردیبهشت)

آزمون پایان ترم

۱۰ نمره

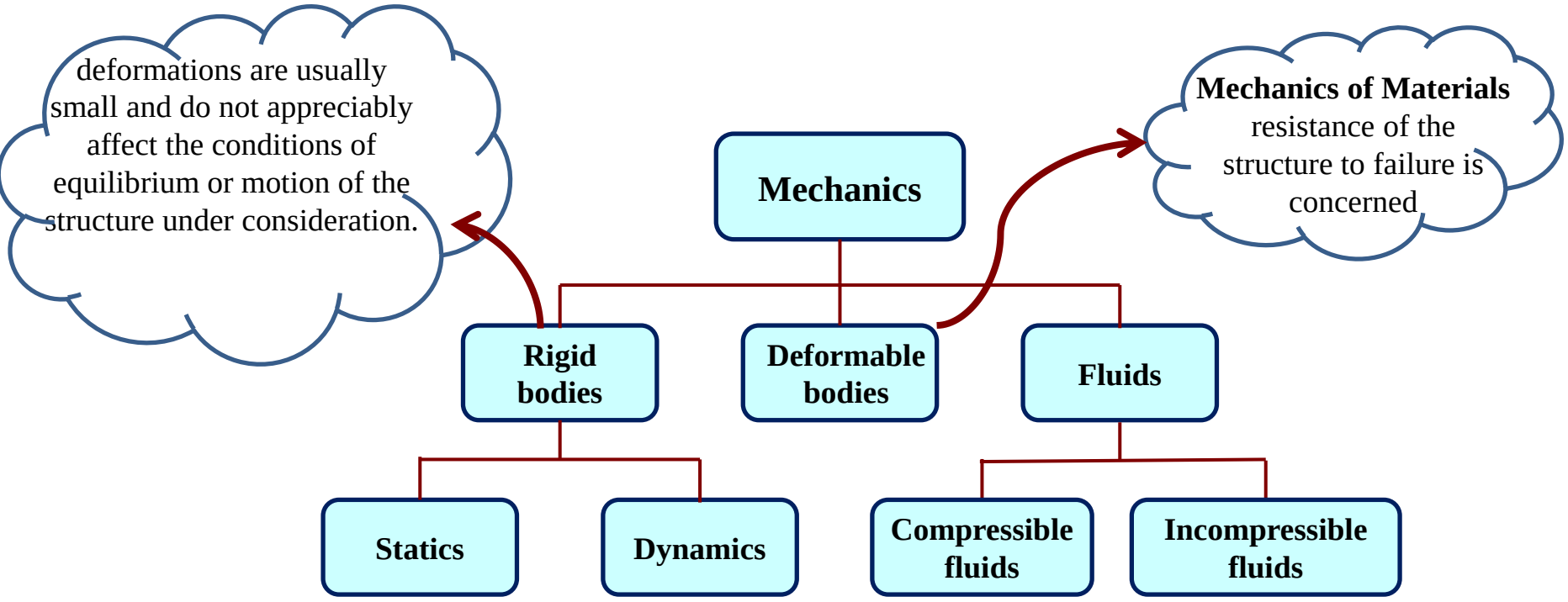
CHAPTER 1

Introduction

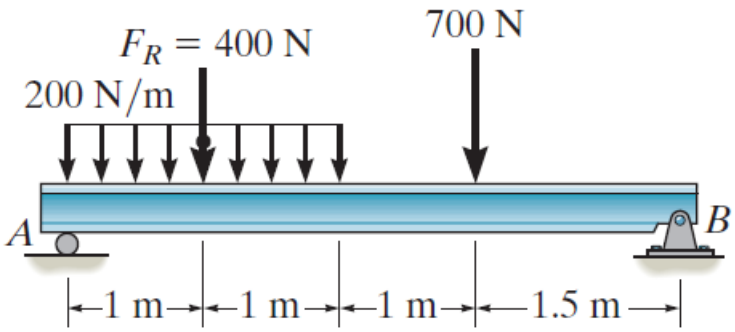
Introduction

❑ What is Mechanics?

Mechanics **:** ***is the science which describes and predicts the conditions of rest or motion of bodies under the action of forces.***



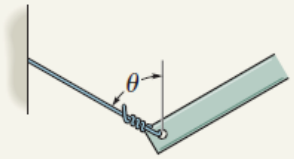
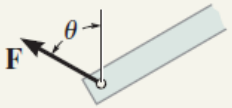
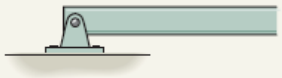
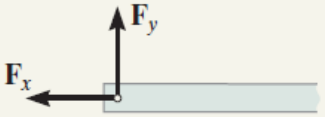
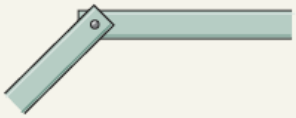
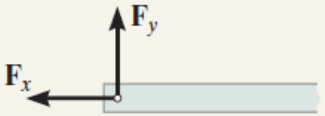
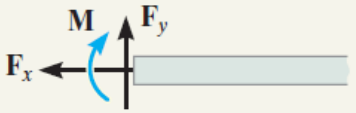
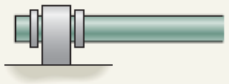
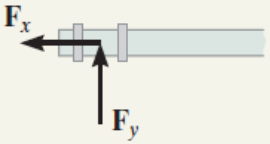
❑ تعادل یک جسم تغییرشکل پذیر



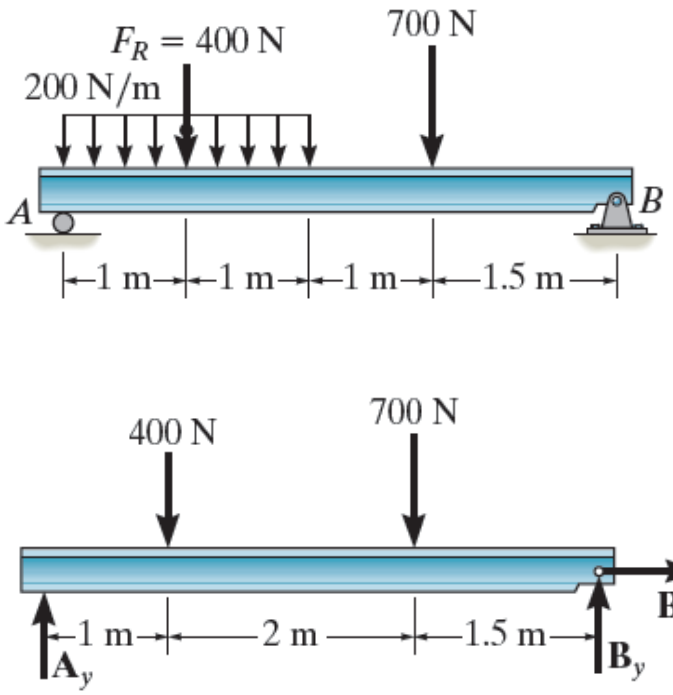
✓ بارهای خارجی

- ✓ بار متمرکز
- ✓ بار گسترده سطحی
- ✓ بار گسترده خطی
- ✓ بار گسترده حجمی

✓ عکس العملهای تکیه گاهی

Type of connection	Reaction	Type of connection	Reaction
 Cable	 One unknown: F	 External pin	 Two unknowns: F_x, F_y
 Roller	 One unknown: F	 Internal pin	 Two unknowns: F_x, F_y
 Smooth support	 One unknown: F	 Fixed support	 Three unknowns: F_x, F_y, M
 Journal bearing	 One unknown: F	 Thrust bearing	 Two unknowns: F_x, F_y

✓ معادلات تعادل

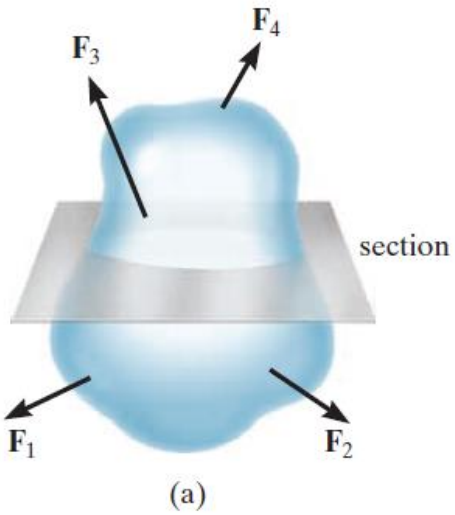


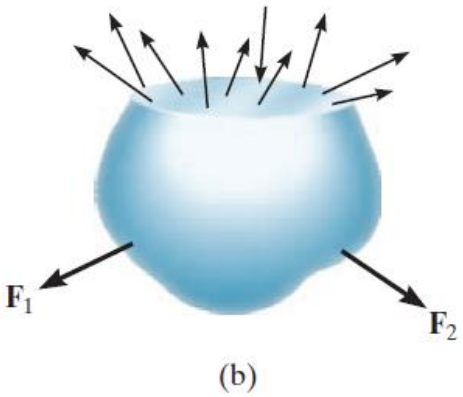
$$\Sigma \mathbf{F} = \mathbf{0}$$
$$\Sigma \mathbf{M}_O = \mathbf{0}$$

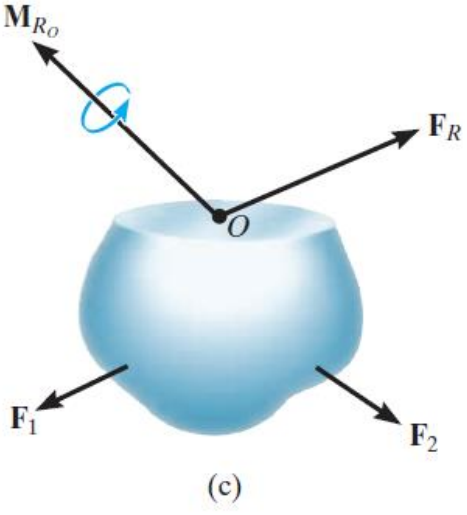
$$\Sigma F_x = 0 \quad \Sigma F_y = 0 \quad \Sigma F_z = 0$$
$$\Sigma M_x = 0 \quad \Sigma M_y = 0 \quad \Sigma M_z = 0$$

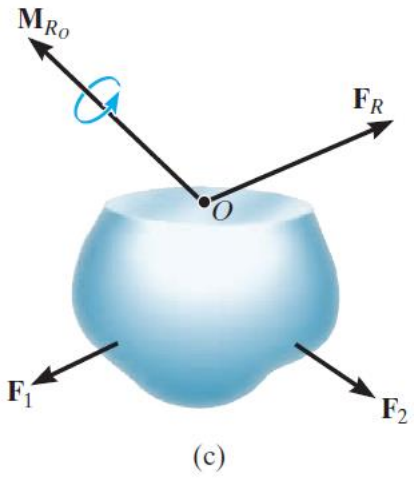
$$\Sigma F_x = 0$$
$$\Sigma F_y = 0$$
$$\Sigma M_O = 0$$

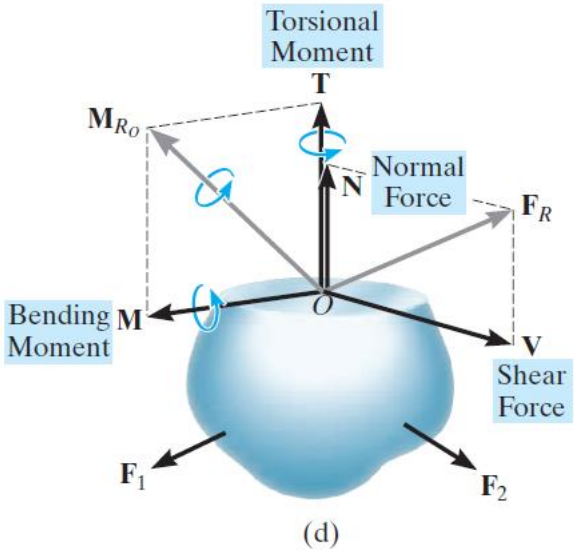
✓ معادلات تعادل











نیروی عمودی N

نیروی برشی V

لنگر پیچشی T

گشتاور خمشی M

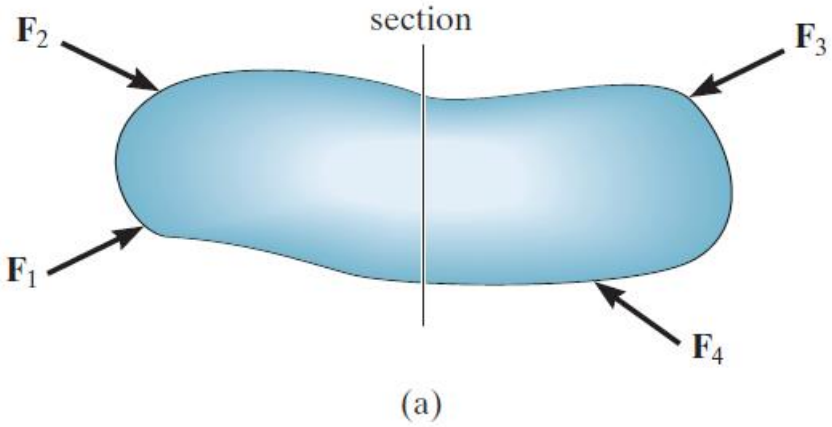
بارگذاری صفحه ای

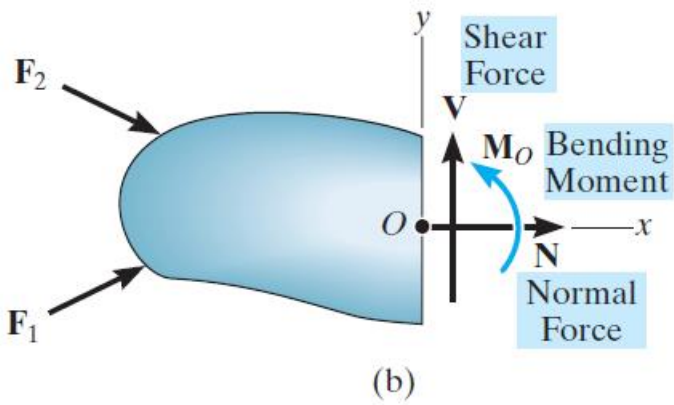
نیروی عمودی N

نیروی برشی V

لنگر پیچشی T

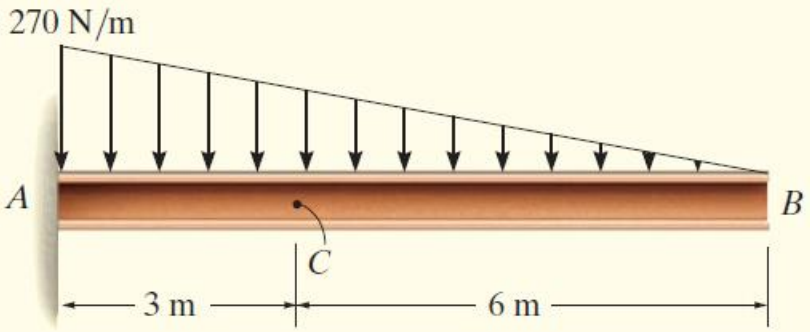
گشتاور خمشی M



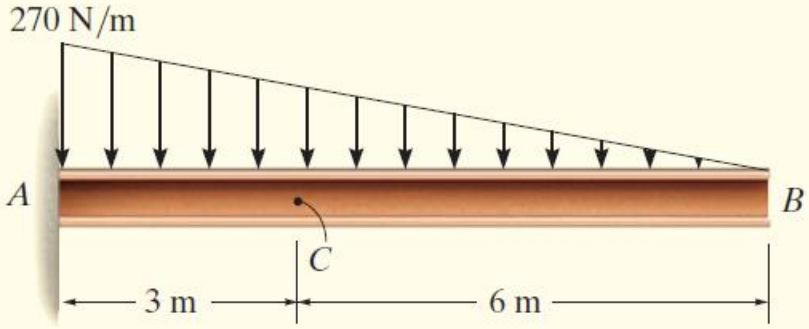


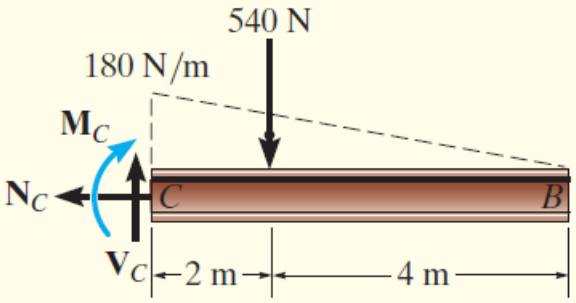
مثال ۱

Determine the resultant internal loadings acting on the cross section at C of the cantilevered beam shown in Fig. 1–4*a*.



مثال





Equations of Equilibrium. Applying the equations of equilibrium we have

$$\pm\rightarrow \Sigma F_x = 0; \qquad -N_C = 0$$

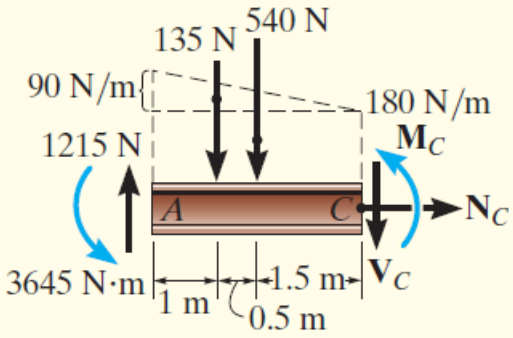
$$N_C = 0 \qquad \textit{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \qquad V_C - 540\ \text{N} = 0$$

$$V_C = 540\ \text{N} \qquad \textit{Ans.}$$

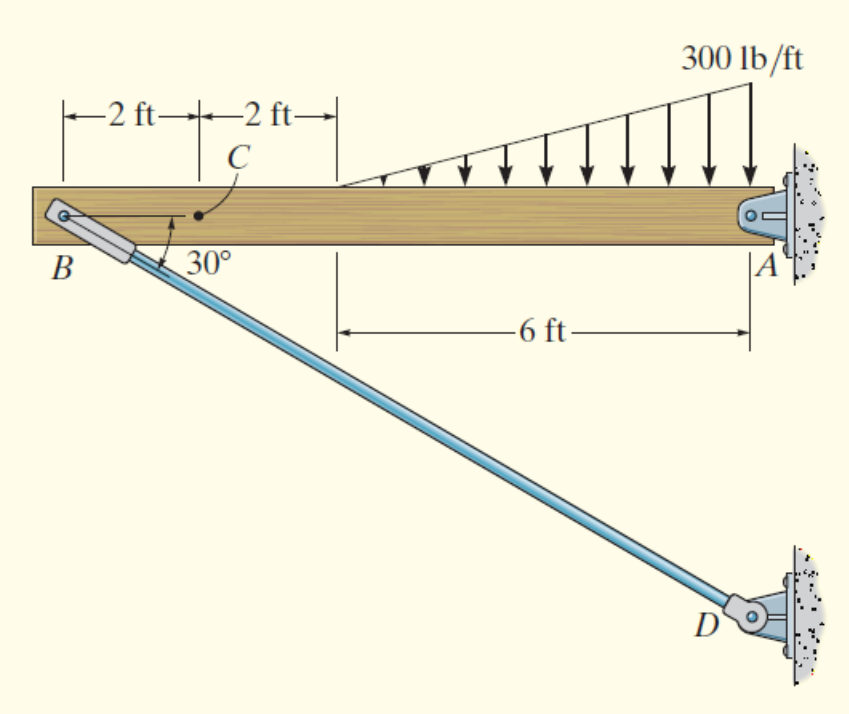
$$\circlearrowleft + \Sigma M_C = 0; \qquad -M_C - 540\ \text{N}(2\ \text{m}) = 0$$

$$M_C = -1080\ \text{N}\cdot\text{m} \qquad \textit{Ans.}$$

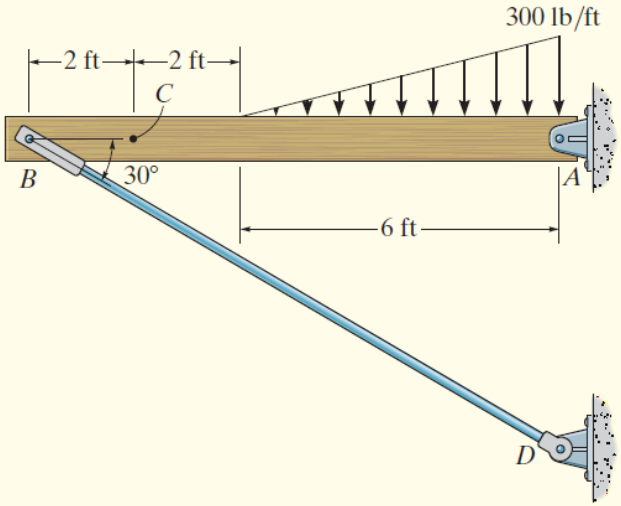


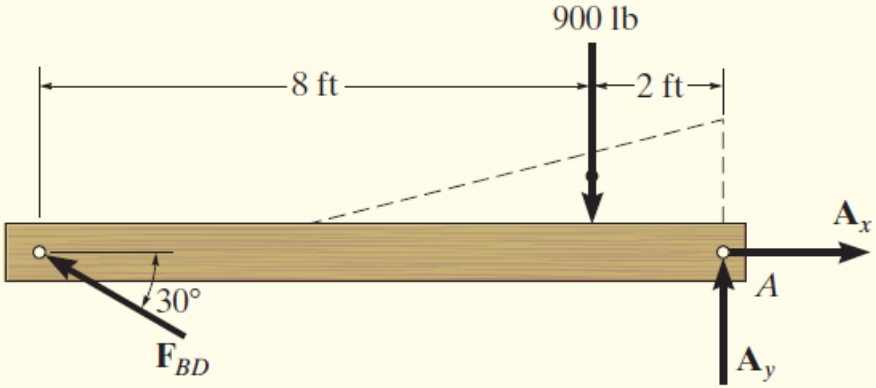
مثال ۲

Determine the resultant internal loadings acting on the cross section at C of the beam shown in Fig. 1–6*a*.



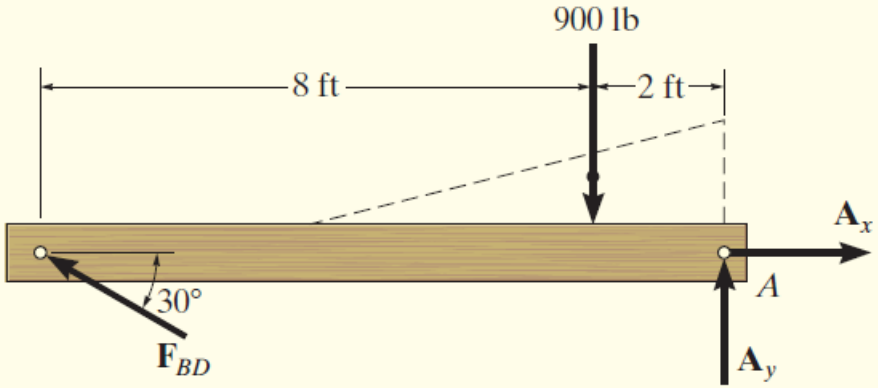
مثال





$$\circlearrowleft + \Sigma M_A = 0; \quad (900\ \text{lb})(2\ \text{ft}) - (F_{BD} \sin 30°)\ 10\ \text{ft} = 0 \quad F_{BD} = 360\ \text{lb}$$

مثال



Free-Body Diagram. Using this result, the free-body diagram of segment BC is shown in Fig. 1–6*c*.

Equations of Equilibrium.

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \qquad N_C - (360\ \text{lb}) \cos 30° = 0$$

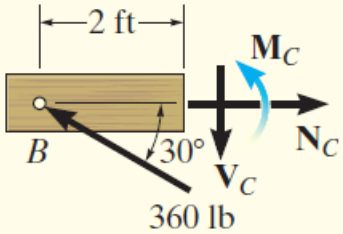
$$N_C = 312\ \text{lb} \qquad \textit{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \qquad (360\ \text{lb}) \sin 30° - V_C = 0$$

$$V_C = 180\ \text{lb} \qquad \textit{Ans.}$$

$$\circlearrowleft + \Sigma M_C = 0; \qquad M_C - (360\ \text{lb}) \sin 30°(2\ \text{ft}) = 0$$

$$M_C = 360\ \text{lb} \cdot \text{ft} \qquad \textit{Ans.}$$



(c)

Introduction

❑ Systems of Units

Name	Length	Time	Mass	Force
International System of Units (SI)	meter (m)	second (s)	kilogram (kg)	newton* (N) $\left(\frac{kg \cdot m}{s^2}\right)$
U.S. Customary (FPS)	foot (ft)	second (s)	slug* $\left(\frac{lb \cdot s^2}{ft}\right)$	pound (lb)

*Derived unit.

Kinematics of Particles

❑ UNITS CONVERSION TABLES

Table 1: Multiples and Submultiples of SI units

Prefix	Symbol	Multiplying Factor	
exa	E	10^{18}	1 000 000 000 000 000 000
peta	P	10^{15}	1 000 000 000 000 000
tera	T	10^{12}	1 000 000 000 000
giga	G	10^{9}	1 000 000 000
mega	M	10^{6}	1 000 000
kilo	k	10^{3}	1 000
hecto*	h	10^{2}	100
deca*	da	10	10
deci*	d	10^{-1}	0.1
centi	c	10^{-2}	0.01
milli	m	10^{-3}	0.001
micro	u	10^{-6}	0.000 001
nano	n	10^{-9}	0.000 000 001
pico	p	10^{-12}	0.000 000 000 001
femto	f	10^{-15}	0.000 000 000 000 001
atto	a	10^{-18}	0.000 000 000 000 000 001

* these prefixes are not normally used

❑ UNITS CONVERSION TABLES

Table 2: Length Units

Millimeters	Centimeters	Meters	Kilometers	Inches	Feet	Yards	Miles
mm	cm	m	km	in	ft	yd	mi
1	0.1	0.001	0.000001	0.03937	0.003281	0.001094	6.21e-07
10	1	0.01	0.00001	0.393701	0.032808	0.010936	0.000006
1000	100	1	0.001	39.37008	3.28084	1.093613	0.000621
1000000	100000	1000	1	39370.08	3280.84	1093.613	0.621371
25.4	2.54	0.0254	0.000025	1	0.083333	0.027778	0.000016
304.8	30.48	0.3048	0.000305	12	1	0.333333	0.000189
914.4	91.44	0.9144	0.000914	36	3	1	0.000568
1609344	160934.4	1609.344	1.609344	63360	5280	1760	1

Table 3: Area Units

Millimeter square	Centimeter square	Meter square	Inch square	Foot square	Yard square
mm^2	cm^2	m^2	in^2	ft^2	yd^2
1	0.01	0.000001	0.00155	0.000011	0.000001
100	1	0.0001	0.155	0.001076	0.00012
1000000	10000	1	1550.003	10.76391	1.19599
645.16	6.4516	0.000645	1	0.006944	0.000772
92903	929.0304	0.092903	144	1	0.111111
836127	8361.274	0.836127	1296	9	1

❑ UNITS CONVERSION TABLES

Table 4: Volume Units

Centimeter cube	Meter cube	Liter	Inch cube	Foot cube	US gallons	Imperial gallons	US barrel (oil)
cm^3	m^3	ltr	in^3	ft^3	US gal	Imp. gal	US brl
1	0.000001	0.001	0.061024	0.000035	0.000264	0.00022	0.000006
1000000	1	1000	61024	35	264	220	6.29
1000	0.001	1	61	0.035	0.264201	0.22	0.00629
16.4	0.000016	0.016387	1	0.000579	0.004329	0.003605	0.000103
28317	0.028317	28.31685	1728	1	7.481333	6.229712	0.178127
3785	0.003785	3.79	231	0.13	1	0.832701	0.02381
4545	0.004545	4.55	277	0.16	1.20	1	0.028593
158970	0.15897	159	9701	6	42	35	1

Table 5: Mass Units

Grams	Kilograms	Metric tonnes	Short ton	Long ton	Pounds	Ounces
g	kg	tonne	shton	Lton	lb	oz
1	0.001	0.000001	0.000001	9.84e-07	0.002205	0.035273
1000	1	0.001	0.001102	0.000984	2.204586	35.27337
1000000	1000	1	1.102293	0.984252	2204.586	35273.37
907200	907.2	0.9072	1	0.892913	2000	32000
1016000	1016	1.016	1.119929	1	2239.859	35837.74
453.6	0.4536	0.000454	0.0005	0.000446	1	16
28	0.02835	0.000028	0.000031	0.000028	0.0625	1

❑ UNITS CONVERSION TABLES

Table 10: High Pressure Units

Bar	Pound/square inch	Kilopascal	Megapascal	Kilogram force/ centimeter square	Millimeter of mercury	Atmospheres
bar	psi	kPa	MPa	kgf/cm^2	mm Hg	atm
1	14.50326	100	0.1	1.01968	750.0188	0.987167
0.06895	1	6.895	0.006895	0.070307	51.71379	0.068065
0.01	0.1450	1	0.001	0.01020	7.5002	0.00987
10	145.03	1000	1	10.197	7500.2	9.8717
0.9807	14.22335	98.07	0.09807	1	735.5434	0.968115
0.001333	0.019337	0.13333	0.000133	0.00136	1	0.001316
1.013	14.69181	101.3	0.1013	1.032936	759.769	1

Table 16: Temperature Conversion Formulas

Degree Celsius (°C)	(°F - 32) x 5/9
	(K - 273.15)
Degree Fahrenheit (°F)	(°C x 9/5) + 32
	(1.8 x K) - 459.67
Kelvin (K)	(°C + 273.15)
	(°F + 459.67) ÷ 1.8