ภาควิชาวิศวกรรมเหมืองแร่และวัสดุ

คณะวิศวกรรมศาสตร์

มหาวิทยาลัยสงขลานครินทร์

การสอบกลางภาคการศึกษาที่ 1 **ปีการศึกษา 2555**

วันอังคารที่ 31 กรกฎาคม 2555 **เวลา: 09.00-12.00 น.**

วิชา: 237-405 Materials and Process Selection **ห้อง: S 103**

<u>คำชี้แจง</u>

1. ข้อสอบมีทั้งหมด 4 ข้อ ให้ทำทุกข้อ
2. ไม่อนุญาตให้นำตำรา เอกสารอื่นๆ เข้าห้องสอบ
3. อนุญาตให้นำเครื่องคิดเลขเข้าห้องสอบได้
4. คะแนนสอบครั้งนี้ คิดเป็น 25 % ของคะแนนรวมทั้งหมด

อ.ชนินทร์ ดำรัสการ

ผู้ออกข้อสอบ

ชื่อ..รหัส...

1.อธิบายแนวคิดการการเลือกใช้วัสดุตามวิธีของ Ashby (5 คะแนน)

ชื่อ...รหัส..

2.อธิบายความหมายของคำต่อไปนี้ (ในความหมายของการเลือกใช้วัสดุ) (4 คะแนน)

Function

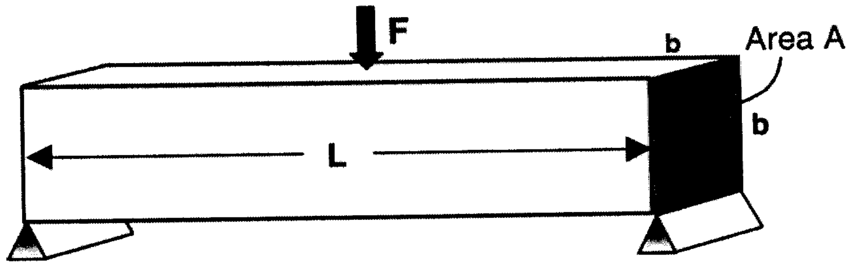
Constraints

Objective

Free variable

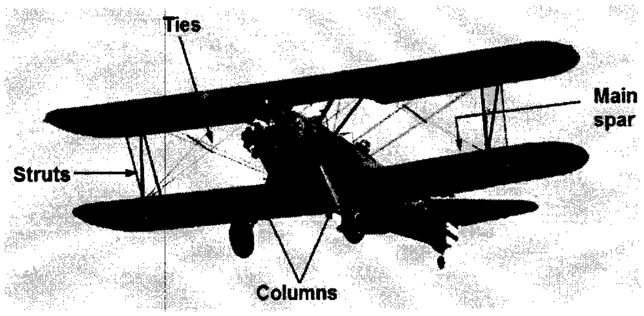
ชื่อ...รหัส..

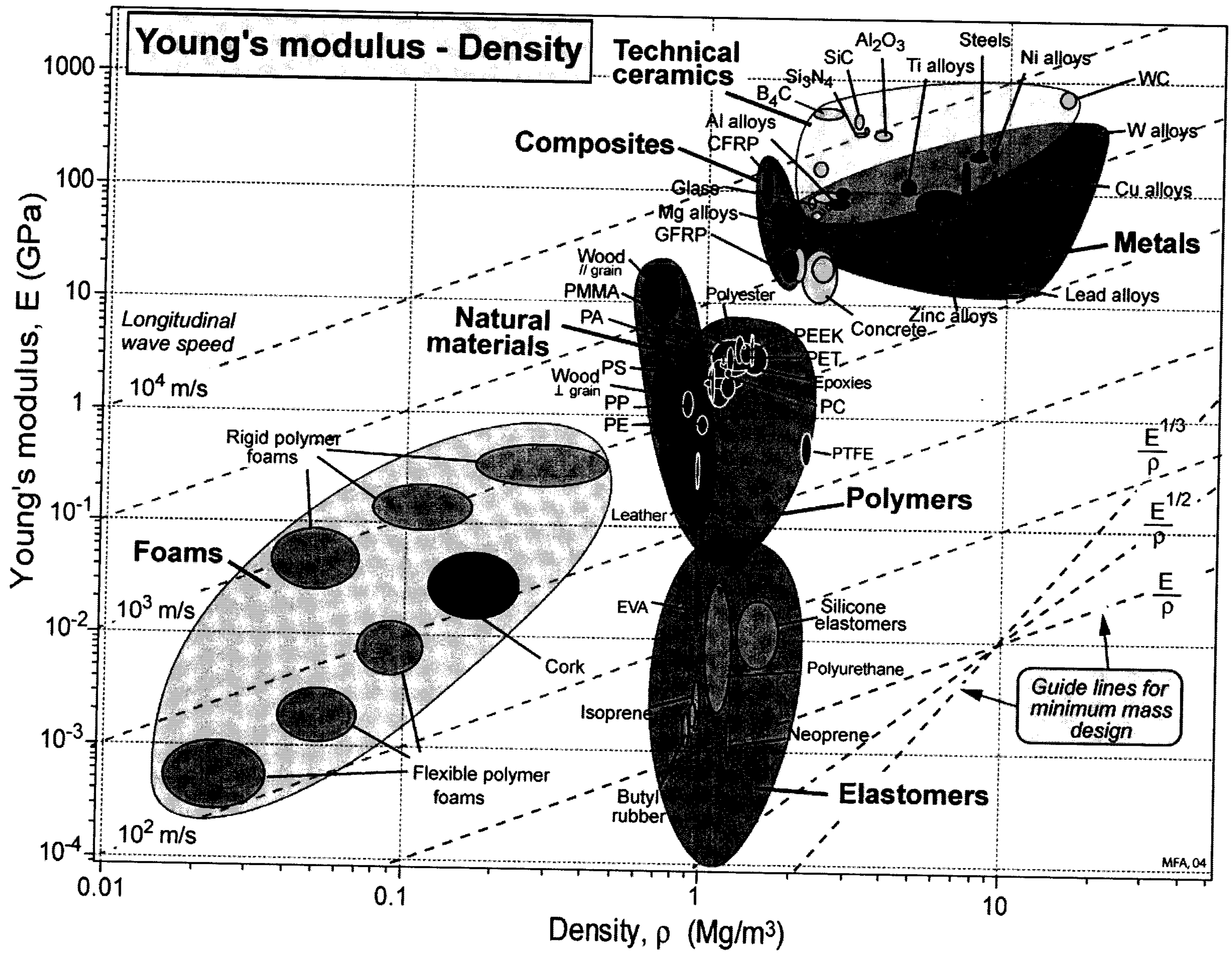
3.คานยาว L พื้นที่หน้าตัด A รับแรง F ดังรูป ให้หา materials index สำหรับคานที่แกร่ง (stiff) และเบา (6 คะแนน)

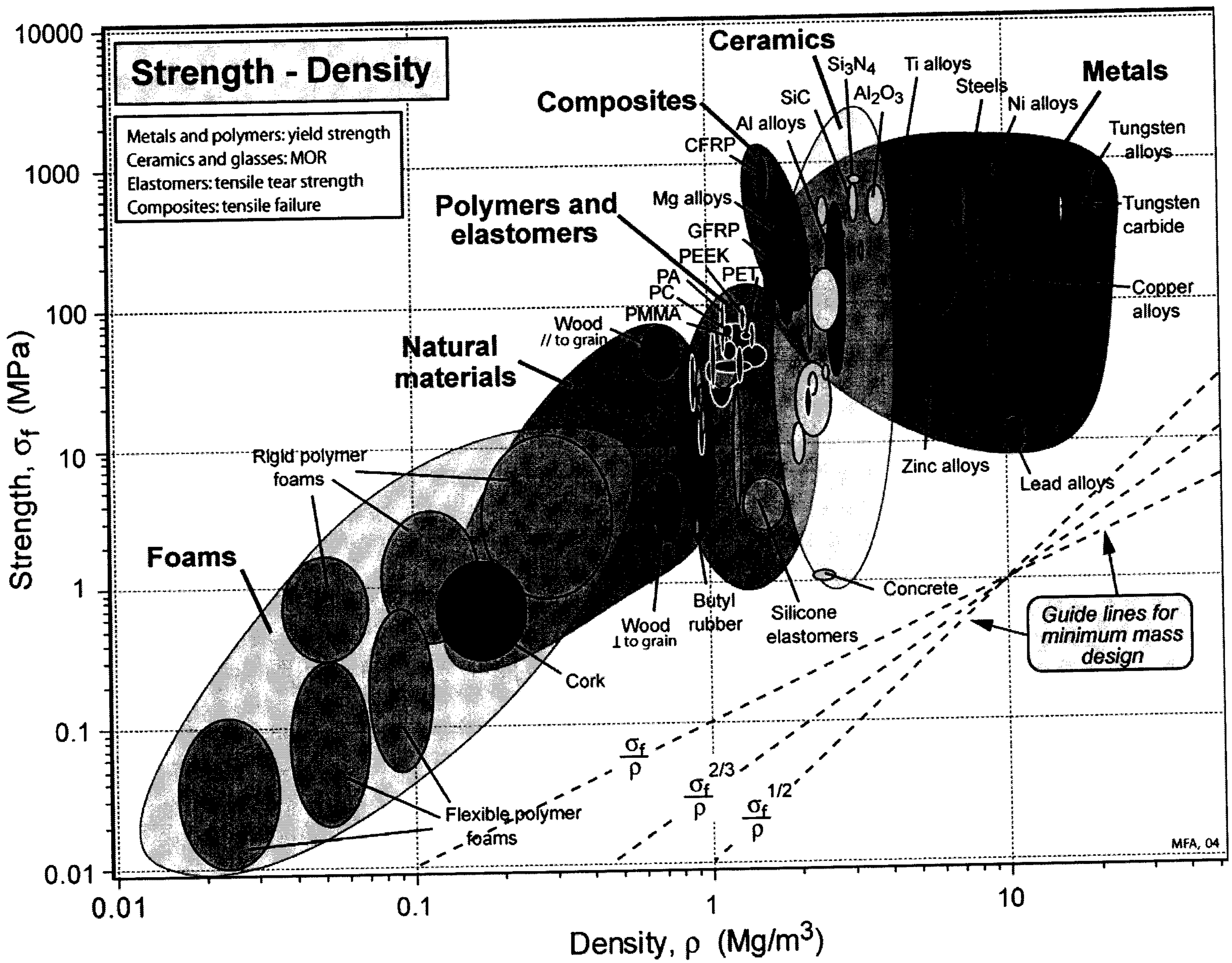


ชื่อ..รหัส..

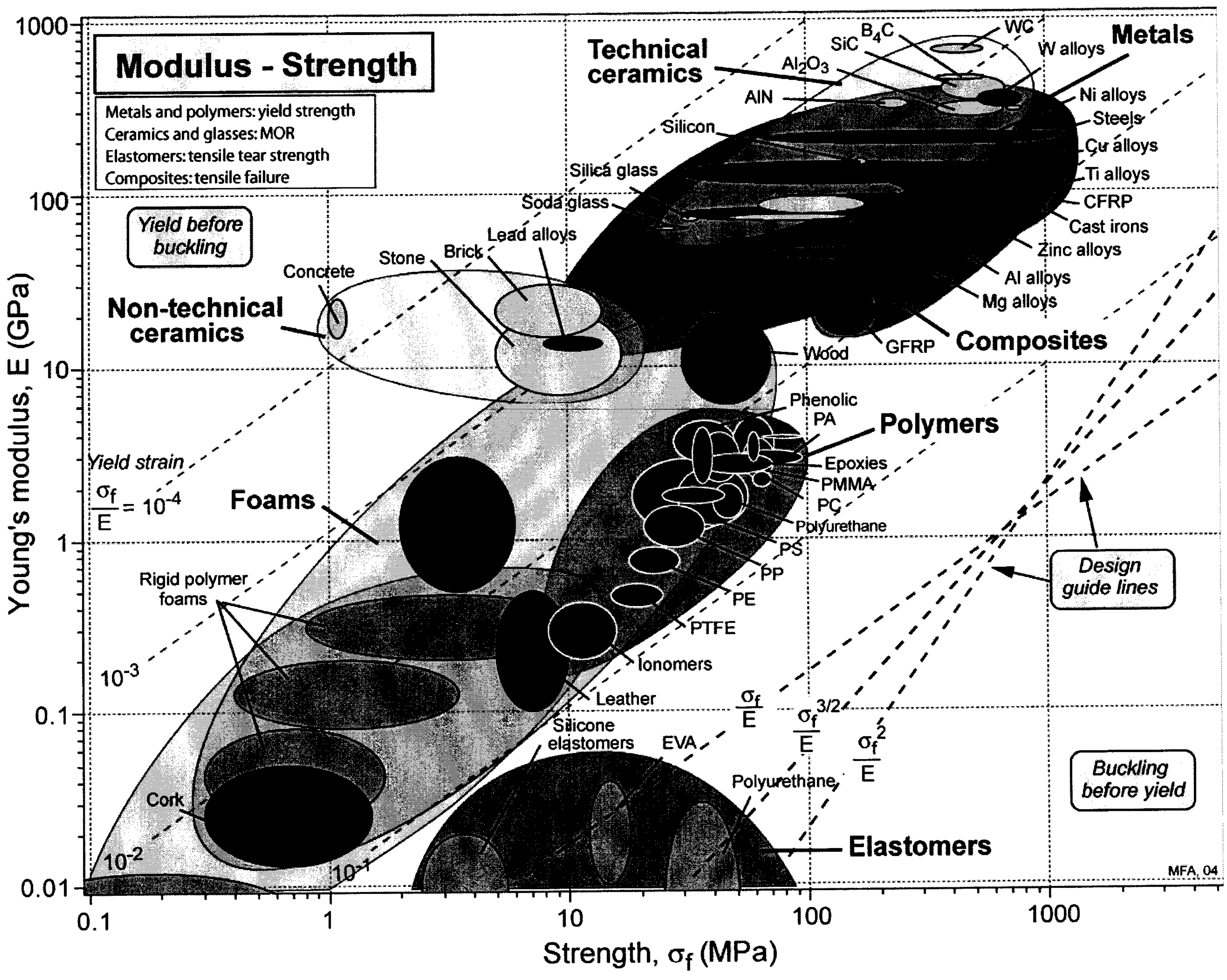
4.แสดงวิธีเลือกวัสดุที่ใช้ทำปีกเครื่องบิน(Main spar) โดยค่าที่คาดว่าจะต้องใช้ให้สมมุติขึ้นมาอย่างสมเหตุสมผล (10 คะแนน)




Young's modulus - Density
Technical ceramics
Composites
Metals
Natural materials
Polymers
Foams
Elastomers
SiC
Al_2O_3
Si_3N_4
B_4C
Steels
Ti alloys
Ni alloys
WC
W alloys
Cu alloys
Lead alloys
Zinc alloys
Concrete
Al alloys
CFRP
Glass
Mg alloys
GFRP
Wood // grain
PMMA
PA
PS
Wood ⊥ grain
PP
PE
Polyester
PEEK
PET
Epoxies
PC
PTFE
Leather
EVA
Silicone elastomers
Polyurethane
Isoprene
Neoprene
Butyl rubber
Rigid polymer foams
Flexible polymer foams
Cork
Longitudinal wave speed
10^4 m/s
10^3 m/s
10^2 m/s
$\frac{E^{1/3}}{\rho}$
$\frac{E^{1/2}}{\rho}$
$\frac{E}{\rho}$
Guide lines for minimum mass design
MFA, 04
Young's modulus, E (GPa)
1000
100
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
Density, ρ (Mg/m³)
0.01
0.1
1
10



Strength - Density
Metals and polymers: yield strength
Ceramics and glasses: MOR
Elastomers: tensile tear strength
Composites: tensile failure
Ceramics
Composites
Metals
Polymers and elastomers
Natural materials
Foams
Si_3N_4
Al_2O_3
SiC
Al alloys
Ti alloys
Steels
Ni alloys
Tungsten alloys
Tungsten carbide
Copper alloys
CFRP
Mg alloys
GFRP
PEEK
PET
PA
PC
PMMA
Wood // to grain
Wood ⊥ to grain
Butyl rubber
Silicone elastomers
Concrete
Zinc alloys
Lead alloys
Rigid polymer foams
Flexible polymer foams
Cork
Guide lines for minimum mass design
$\frac{\sigma_f}{\rho}$
$\frac{\sigma_f^{2/3}}{\rho}$
$\frac{\sigma_f^{1/2}}{\rho}$
MFA, 04
Strength, σ_f (MPa)
Density, ρ (Mg/m^3)
10000
1000
100
10
1
0.1
0.01
0.01
0.1
1
10


Modulus - Strength
Metals and polymers: yield strength
Ceramics and glasses: MOR
Elastomers: tensile tear strength
Composites: tensile failure
Yield before buckling
Buckling before yield
Design guide lines
Yield strain
$\frac{\sigma_f}{E} = 10^{-4}$
10^{-3}
10^{-2}
10^{-1}
$\frac{\sigma_f}{E}$
$\frac{\sigma_f^{3/2}}{E}$
$\frac{\sigma_f^2}{E}$
Technical ceramics
WC
B_4C
SiC
Al_2O_3
AlN
Silicon
Silica glass
Soda glass
Metals
W alloys
Ni alloys
Steels
Cu alloys
Ti alloys
CFRP
Cast irons
Zinc alloys
Al alloys
Mg alloys
Composites
GFRP
Wood
Non-technical ceramics
Concrete
Stone
Brick
Lead alloys
Polymers
Phenolic
PA
Epoxies
PMMA
PC
Polyurethane
PS
PP
PE
PTFE
Ionomers
Leather
Foams
Rigid polymer foams
Cork
Elastomers
Silicone elastomers
EVA
Polyurethane
Young's modulus, E (GPa)
Strength, σ_f (MPa)
0.01
0.1
1
10
100
1000
MFA, 04

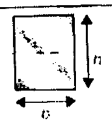
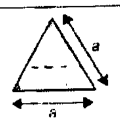
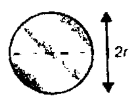
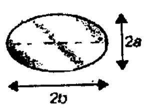
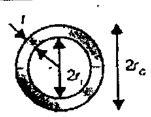
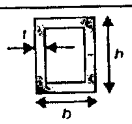
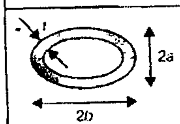
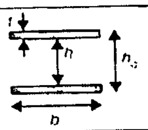
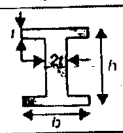
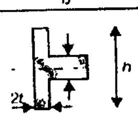
Section Shape	Area A m^2	Moment I m^4	Moment K m^4	Moment Z m^3	Moment Z_p m^3
	bh	$\frac{bh^3}{12}$	$\frac{bh^3}{3}(1-0.58\frac{b}{h})$ $(h>b)$	$\frac{bh^2}{6}$	$\frac{bh^2}{4}$
	$\frac{\sqrt{3}}{4}a^2$	$\frac{a^4}{32\sqrt{3}}$	$\frac{\sqrt{3}a^4}{80}$	$\frac{a^3}{32}$	$\frac{3a^3}{64}$
	πr^2	$\frac{\pi}{4}r^4$	$\frac{\pi}{2}r^4$	$\frac{\pi}{4}r^3$	$\frac{\pi}{3}r^3$
	πab	$\frac{\pi}{4}a^3b$	$\frac{\pi a^3b^3}{(a^2+b^2)}$	$\frac{\pi}{4}a^2b$	$\frac{\pi}{3}a^2b$
	$\pi(r_o^2-r_i^2)$ $\approx 2\pi rt$	$\frac{\pi}{4}(r_o^4-r_i^4)$ $\approx \pi r^3t$	$\frac{\pi}{2}(r_o^4-r_i^4)$ $\approx 2\pi r^3t$	$\frac{\pi}{4r_o}(r_o^4-r_i^4)$ $\approx \pi r^2t$	$\frac{\pi}{3}(r_o^3-r_i^3)$ $\approx \pi r^2t$
	$2t(h+b)$ $(h, b>>t)$	$\frac{1}{6}h^3t(1+3\frac{b}{h})$	$\frac{2tb^2h^2}{(h+b)}(1-\frac{t}{h})^4$	$\frac{1}{3}h^2t(1+3\frac{b}{h})$	$bht(1+\frac{h}{2b})$
	$\pi(a+b)t$ $(a, b>>t)$	$\frac{\pi}{4}a^3t(1+\frac{3b}{a})$	$\frac{4\pi(ab)^{5/2}t}{(a^2+b^2)}$	$\frac{\pi}{4}a^2t(1+\frac{3b}{a})$	$\pi abt(2+\frac{a}{b})$
	$b(h_o-h_i)$ $\approx 2bt$ $(h, b>>t)$	$\frac{b}{12}(h_o^3-h_i^3)$ $\approx \frac{1}{2}bth_o^2$	-	$\frac{b}{6h_o}(h_o^3-h_i^3)$ $\approx bth_o$	$\frac{b}{4}(h_o^2-h_i^2)$ $\approx bth_o$
	$2t(h+b)$ $(h, b>>t)$	$\frac{1}{6}h^3t(1+3\frac{b}{h})$	$\frac{2}{3}bt^3(1+4\frac{h}{b})$	$\frac{1}{3}h^2t(1+3\frac{b}{h})$	$bht(1+\frac{h}{2b})$
	$2t(h+b)$ $(h, b>>t)$	$\frac{t}{6}(h^3+4bt^2)$	$\frac{t^3}{3}(8b+h)$	$\frac{t}{3h}(h^3+4bt^2)$	$\frac{th^2}{2}\{1+\frac{2t(b-2t)}{h^2}\}$

FIGURE B.2

B.3 ELASTIC BENDING OF BEAMS

When a beam is loaded by a force, F, or moments, M, the initially straight axis is deformed into a curve. If the beam is uniform in section and properties, long in relation to its depth, and nowhere stressed beyond the elastic limit, the deflection, δ, and the angle of rotation, θ, can be calculated using elastic beam theory (see Section B.16). The basic differential equation describing the curvature of the beam at a point x along its length is

$$EI\frac{d^2y}{dx^2} = M$$

where y is the lateral deflection, and M is the bending moment at the point x on the beam. E is Young's modulus, and I is the second moment of area (Section B.2). When M is constant this becomes

$$\frac{M}{I} = E\left(\frac{1}{R} - \frac{1}{R_o}\right)$$

where R_o is the radius of curvature before applying the moment and R is the radius after it is applied. Deflections δ and rotations θ are found by integrating these equations along the beam.

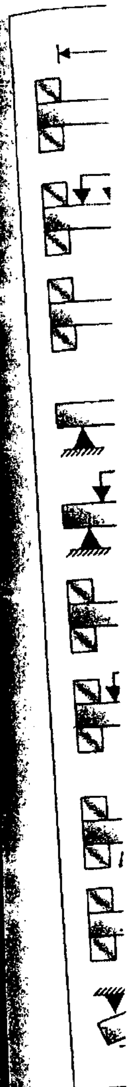
The stiffness of the beam is defined by

$$S = \frac{F}{\delta} = \frac{C_1 EI}{L^3}$$

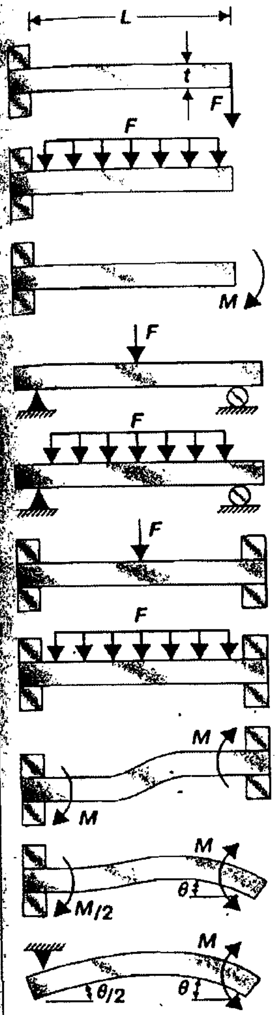
It depends on Young's modulus, E, for the material of the beam, on its length, L, and on the second moment of its section, I. The end slope of the beam, θ, is given by

$$\theta = \frac{FL^2}{C_2 EI}$$

Equations for the deflection, δ, and-end slope, θ, of beams for various common modes of loading are shown on the facing page together with values of C_1 and C_2.



FIGU



Case	C_1	C_2
1	3	2
2	8	6
3	2	1
4	48	16
5	$\frac{384}{5}$	24
6	192	-
7	384	-
8	6	-
9	-	4
10	-	3

$$\delta = \frac{FL^3}{C_1EI} = \frac{ML^2}{C_1EI}$$

$$\theta = \frac{FL^2}{C_2EI} = \frac{ML}{C_2EI}$$

F = Young's modulus (N/m^2)
δ = Deflection (m)
F = Force (N)
M = Moment (Nm)
L = Length (m)
b = Width (m)
t = Depth (m)
θ = End slope (–)
I = See Table B.2 (m^4)
y = Distance from neutral axis (m)
R = Radius of curvature (m)

$$\frac{\sigma}{y} = \frac{M}{I} = \frac{E}{R}$$

FIGURE B.3

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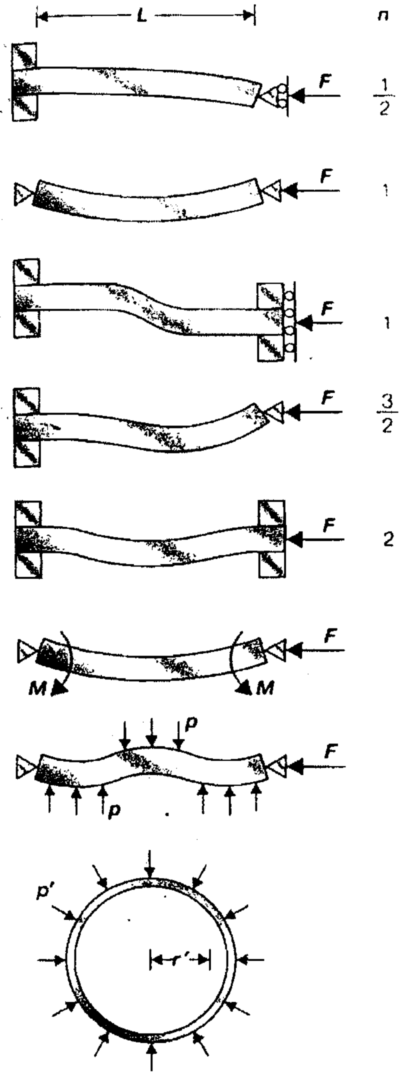
Chapter 9).



$$F_{crit} = \frac{n^2\pi^2 EI}{L}$$

or $$\frac{F_{crit}}{A} = \frac{n^2\pi^2 E}{(L/r)^2}$$

F = Force (N)
M = Moment (Nm)
E = Young's modulus (N/m^3)
L = Length (m)
A = Section area (m^2)
I = See Table B 2 (m^4)
r = Gyration radius $(I/A)^{1/2}$ (m)
k = Foundation stiffness (N/m^2)
n = Half-wavelengths in buckled shape
p' = Pressure (N/m^2)

$$F_{crit} = \frac{\pi^2 EI}{L^2} - \frac{M^2}{4EI}$$

$$F_{crit} = \frac{n^2\pi^2 EI}{L^2} - \frac{kL^2}{n^2}$$

$$p'_{crit} = \frac{3EI}{(r')^3}$$

FIGURE B.5