UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2008/2009

November 2008

EAS 253/3 – Theory of Structures
[Teori Struktur]

Duration: 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of **THIRTEEN (13)** pages of printed material including appendix before you begin the examination.
*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **TIGA BELAS (13)** muka surat bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

Instructions: This paper contains **SEVEN (7)** questions. Answer **THREE (3)** compulsory questions in Part A and choose **TWO (2)** questions in Part B.
*[**Arahan**: Kertas ini mengandungi **TUJUH (7)** soalan. Jawab **TIGA (3)** soalan wajib di Bahagian A dan pilih **DUA (2)** soalan di Bahagian B.*

You may answer the question either in Bahasa Malaysia or English.
[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

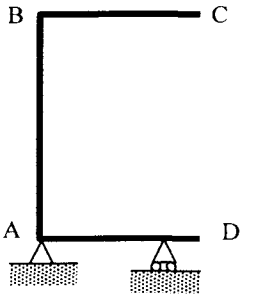
All questions **MUST BE** answered on a new sheet.
*[Semua jawapan **MESTILAH** dijawab pada muka surat baru.]*

Write the answered question numbers on the cover sheet of the answer script.
[Tuliskan nombor soalan yang dijawab di luar kulit buku jawapan anda.]

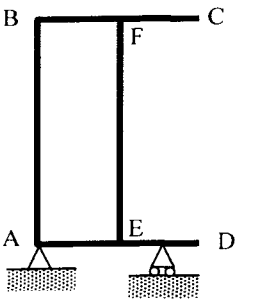
PART A

1. (a) Prove that structures shown in Figure 1(i) is statically determinate.

Buktikan bahawa struktur yang ditunjukkan dalam Rajah 1(i) adalah struktur bolehtentu statik.



(i)



(ii)

Figure/*Rajah* 1

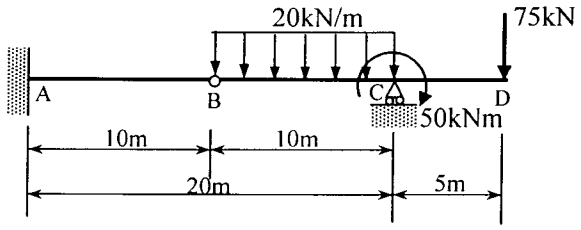
If an additional member EF is added to Figure 1(i) as shown in Figure 1(ii), check statical determinacy of the modified structure. Note that joint E and F are rigid joints.

Sekiranya satu anggota tambahan EF ditambahkan kepada Rajah 1(i) seperti yang ditunjukkan dalam Rajah 1(ii), semak kebolehtentuan statik struktur yang diubahsuai. Perhatikan bahawa sambungan E dan F adalah sambungan jenis tegar.

[3 marks/*markah*]

(b) Figure 2 shows a beam with a rigid support at A, a roller support at C and an overhang portion CD. A hinge joint presents at B located along member AC. The beam is loaded with a uniformly distributed load 20kN/m along portion BC, a point load 75kN at free end D and a couple 50kNm at support C. Draw the shear force and bending moment diagrams for the beam. Sketch also the qualitative deflected shape.

Rajah 2 menunjukkan satu rasuk dengan penyokong tegar di A, penyokong rola di C dan satu bahagian terjulur CD. Satu sambungan jenis sendi berada di B yang terletak di atas anggota AC. Rasuk berkenaan membawa beban teragih seragam 20kN/m di sepanjang bahagian BC, satu beban tertumpu 75kN pada hujung bebas D dan satu momen gandingan 50kNm pada penyokong C. Lukiskan gambarajah daya ricih dan momen lentur untuk rasuk berkenaan. Lakarkan juga bentuk terpesong kualitatif.



Figure/*Rajah* 2

[17 marks/*markah*]

2. (a) Define the first and the second moment-area theorem.

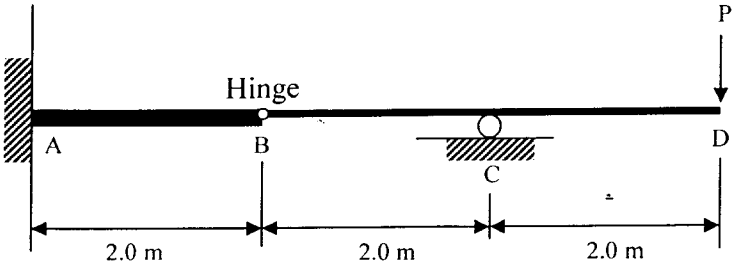
[4 marks/*markah*]

Berikan definisi untuk teori momen-luas pertama dan kedua.

(b) The beam shown in Figure 3 is subjected to a concentrated load P at D. The moment of inertia of segment AB of the beam is 2I, whereas segments BC and CD have moment of inertia I. Given I = 90 x 10^6mm^4 and elastic modulus of 200GPa, determine the magnitude of force P that can be applied at point D so that the vertical displacement at C does not exceed 2mm downward using the **conjugate-beam method**. Assume A is fixed support, B is a hinge and C is a roller support.

[16 marks/*markah*]

Rasuk yang ditunjukkan dalam Rajah 3 dibebani satu beban tertumpu P di D. Momen inersia bagi rasuk di bahagian AB adalah 2I, manakala di bahagian BC dan CD adalah I. Diberi nilai $I = 90 \times 10^6$ *mm*^{4} *dan modulus keanjalan adalah 200GPa, tentukan magnitud daya P yang boleh dikenakan di titik D supaya anjakan pugak di C tidak melebihi 2mm ke bawah dengan menggunakan* ***kaedah rasuk-konjugat****. Anggap A adalah penyokong terikat tegar, B adalah engsel dan C adalah penyokong rola.*



Figure/*Rajah* 3

3. (a) Figure 4(i) to (iii) shows **THREE (3)** different types of plane trusses. Check for the statical determinacy of the trusses. All support and member connections are pinned.

[3 marks/*markah*]

Rajah 4(i) hingga (iii) menunjukkan ***TIGA (3)*** *kekuda satah yang berbeza. Semak kebolehtentuan statik kekuda berkenaan. Semua penyokong dan sambungan adalah pin.*

(b) Figure 5 shows a plane trusses with pinned supports at A and roller support at F. Find the reactions at supports A and F. Identify any zero force members, if any.

[6 marks/*markah*]

Rajah 5 menunjukkan satu kekuda satah dengan penyokong cemat pada A dan penyokong rola pada F. Kira nilai daya tindakbalas di penyokong A dan F. Kenalpasti anggota kekuda yang mungkin mempunyai daya sifar, sekiranya ada.

(c) Determine forces in member DE, EC and CF for the truss shown in Figure 5 by using section method and classify whether they are in tension or compression.

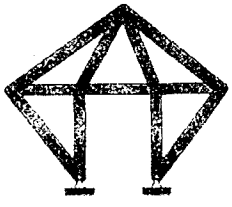
[6 marks/*markah*]

Kira daya dalam anggota DE, EC dan CF bagi kekuda dalam Rajah 5 menggunakan kaedah keratan. Nyatakan samada anggota tersebut mengalami daya mampatan atau tegangan.

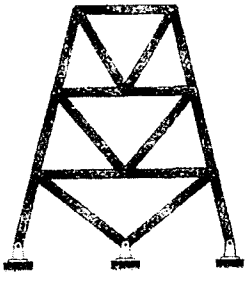
(d) Determine forces in member AC and CD for the truss shown in Figure 5 by using joint method. Classify whether they are in tension or compression.

[5 marks/*markah*]

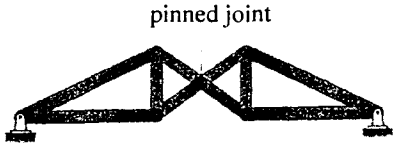
Kira daya bagi anggota AC dan CD bagi kekuda dalam, Rajah 5 menggunakan kaedah sambungan. Nyatakan samada anggota tersebut mengalami daya mampatan atau tegangan.



(i)

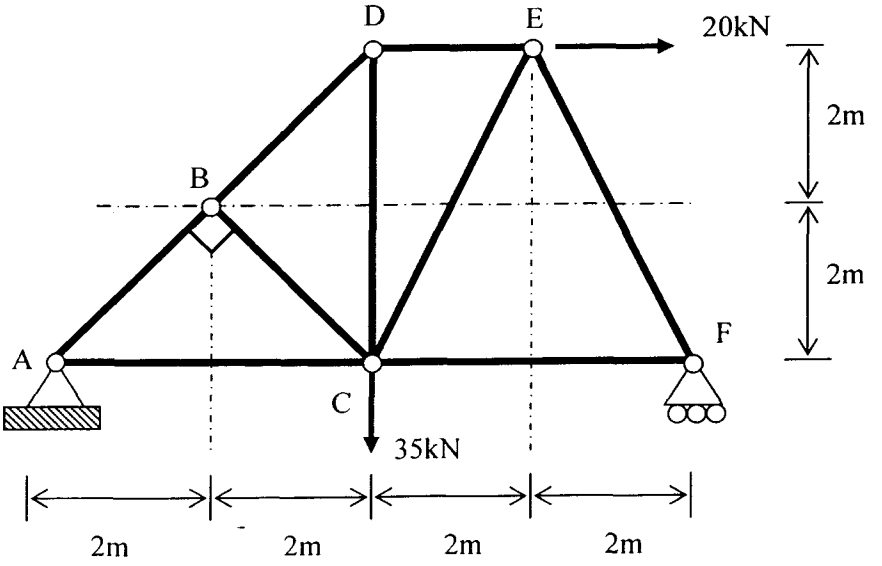


(ii)



(iii)

Figure/Rajah 4



Figure/*Rajah* 5

PART B : Choose TWO (2) questions

4. (a) Describe briefly two types of cables.

[2 marks/*markah*]

*Jelaskan secara ringkas **DUA (2)** jenis kabel .*

(b) The cable system shown in Figure 6 carries a uniformly distributed load of 5kN/m between supports A and B with a span of 40m. Support A is 5m higher than support B. Determine:

(i) the total length of cable, S given by $S = l_1 + l_2 + \frac{2d_1^2}{3l_1} + \frac{2d_2^2}{3l_2}$ where $\frac{l_1}{l_2} = \sqrt{\frac{d_1}{d_2}}$

(ii) the maximum and minimum tension between A and B (T_{min} and T_{max})

(iii) the tension in anchor cables (T_A' and T_B') and vertical and horizontal reactions at supports (R_{VA}, R_{HA} and R_{VB}, R_{HB})

(iv) size of the cable, if the allowable stress = 15500kN/m^2.

[18 marks/*markah*]

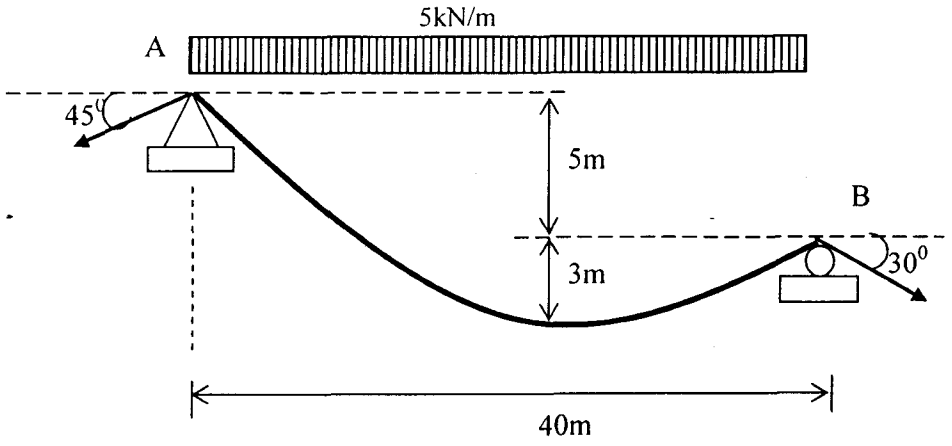
SATU (1) *sistem kabel seperti yang ditunjukkan dalam Rajah 6, menanggung beban teragih seragam 5kN/m di sepanjang rentang antara kedua-dua penyokong A dan B yang berjarak 40m antara satu sama lain. Penyokong A berada 5m lebih tinggi daripada penyokong B. Kira:*

(i) *panjang keseluruhgan kabel,* S iaitu $S = l_1 + l_2 + \frac{2d_1^2}{3l_1} + \frac{2d_2^2}{3l_2}$ dan $\frac{l_1}{l_2} = \sqrt{\frac{d_1}{d_2}}$.

(ii) nilai tegangan maksima dan minima kabel antara penyokong A dan B (T_{min} dan T_{max}).

(iii) tegangan kabel sauh (T_A' dan T_B')dan tindakbalas menegak dan mengufuk di penyokong (R_{VA}, R_{HA} dan R_{VB}, R_{HB})

(iv) saiz keratan rentas kabel yang diperlukan sekiranya tegasan dibenarkan kabel tersebut ialah 15500 kN/m^2.



Figure/*Rajah* 6

5. (a) What is the main difference between arch structures and cable structures?.

[2 marks/*markah*]

Apakah perbezaan utama antara struktur gerbang dan struktur kabel?

(b) An unsymmetrical three pinned arch shown in Figure 7 is in the form of $y = \frac{4hx(L-x)}{L^2}$, where L= 40m and h = 8m. Support A is 2.88m lower than support E. It is designed to carry a uniformly distributed load of 5kN/m spanning 26m on span BCDE and a point load of 10kN at D. A horizontal point load of 20kN is applied at point B. Joint A, C and E are hinged.

Determine:

(i) support reactions at A and E

(ii) bending moment at B and D

(iii) shear force, Q and thrust, N at point B and D (with loading)

(iv) sketch also the bending moment diagram of the arch

[18 marks/*markah*]

SATU (1) *Gerbang tiga engsel tidak simetri seperti di Rajah 7 adalah dalam bentuk persamaan* $y = \frac{4hx(L-x)}{L^2}$, *iaitu L = 40m dan h = 8m. Penyokong A berada 2.88m ke bawah daripada penyokong E. Ia direkabentuk untuk membawa beban teragih seragam sebanyak 5kN/m di sepanjang rentang 26m di bahagian BCDE.* ***SATU (1)*** *beban tertumpu pugak 10kN di D dan* ***SATU (1)*** *beban tertumpu ufuk 20kN di B. Sambungan A, C dan E adalah engsel.*

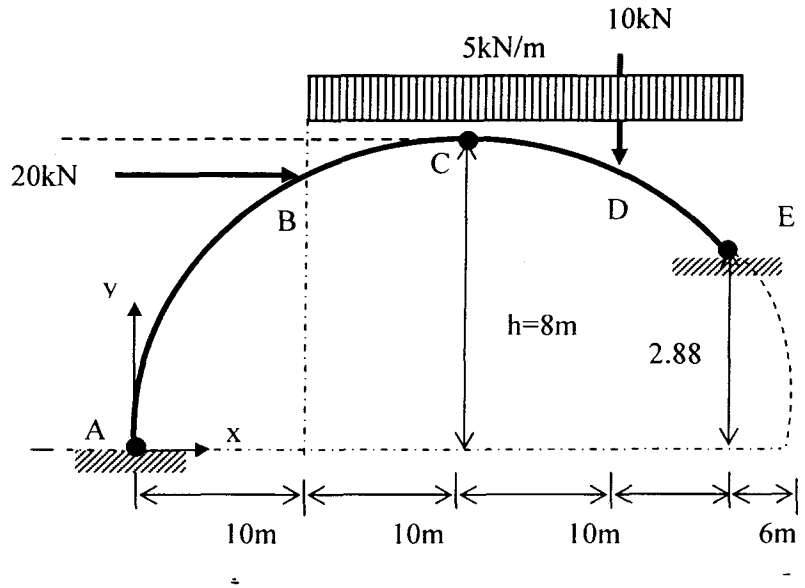
Tentukan:

(i) daya tindakbalas di penyokong A dan E.

(ii) momen lentur di titik B dan D.

(iii) daya ricih Q dan daya paksi N di titik B dan D (dengan beban kenaan)

(iv) lakarkan juga gambarajah momen lentur untuk gerbang tersebut.

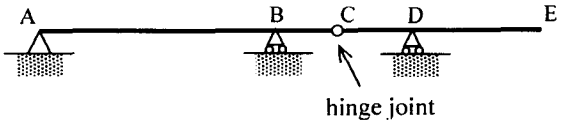


Figure/*Rajah* 7

6. (a) Figure 8 shows a statically determinate beam. Suggest a way how the beam can be turned into a statically indeterminate one with degree of statical indeterminacy equals to 1. Provide a sketch showing your suggestion.

[3 marks/*markah*]

Rajah 8 menunjukkan satu rasuk bolehtentu statik. Cadangkan satu cara bagaimana rasuk berkenaan boleh ditukarkan kepada rasuk tidakbolehtentu statik dengan darjah ketidakbolehtentuan statik sama dengan 1. Tunjukkan cadangan anda dengan menggunakan satu lakaran.

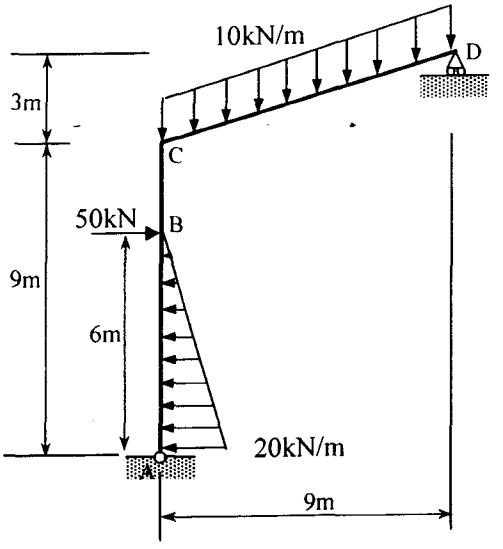


Figure/*Rajah* 8

(b) Figure 9 shows a frame with pinned and roller supports at A and D, respectively. It is loaded by a uniformly distributed load of 10kN/m along member CD, a horizontal concentrated load of 50kN at B and a linearly distributed load varying from 20kN/m at A to 0kN/m at B. Draw the shear force and bending moment diagrams for the frame. Sketch also the qualitative deflected shape.

[17 marks/*markah*]

Rajah 9 menunjukkan satu kerangka dengan penyokong pin pada A dan penyokong rola pada D. Kerangka berkaitan dibebankan dengan satu beban teragih seragam 10kN/m di sepanjang anggota CD, satu beban tertumpu ufuk 50kN pada B dan satu beban teragih lelurus yang berubah dari 20kN/m pada A sehingga 0kN/m pada B. Lukiskan gambarajah daya ricih dan momen lentur untuk kerangka berkenaan. Lakarkan juga bentuk terpesong kualitatif.



Figure/*Rajah* 9

7. (a) Draw the influence lines diagram for the vertical reaction at all supports and shear force at A using the **Müller-Breslau's Principle** for the beam shown in Figure 10(i) to (iii).

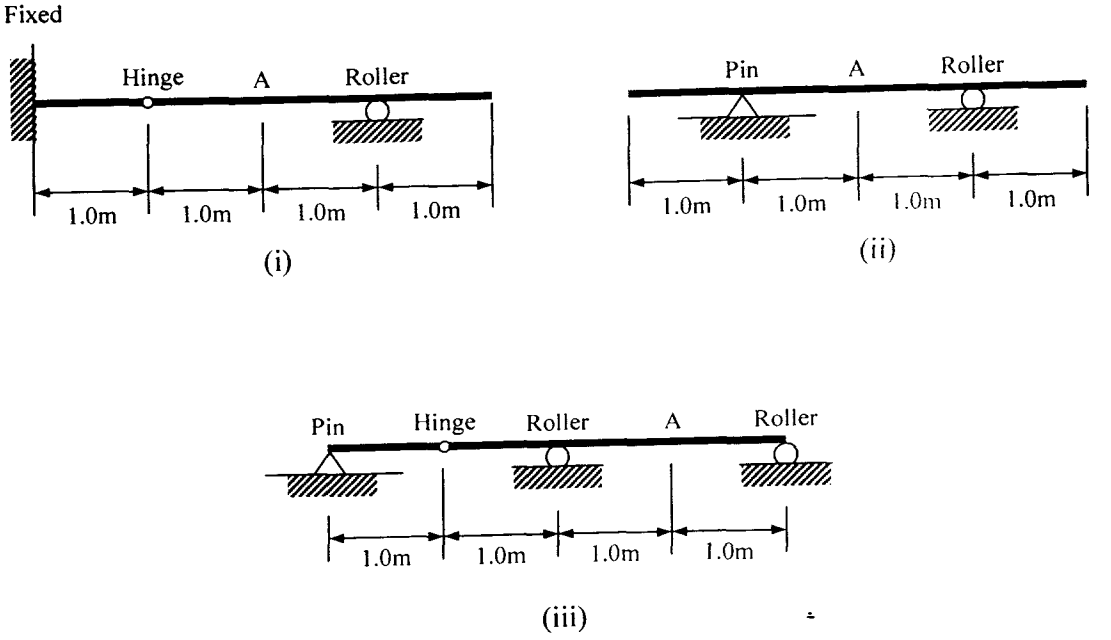
[10 marks/*markah*]

Lukiskan gambarajah garis imbas bagi tindak balas di semua penyokong dan daya ricih di A menggunakan ***Prinsip Müller-Breslau*** *untuk rasuk yang ditunjukkan dalam Rajah 10(i) hingga (iii).*

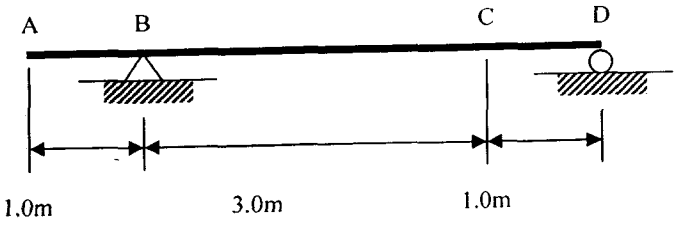
(b) A beam subjected to a moving load which travels from A to D is shown in Figure 11(i). The beam is pin supported at B and supported by a roller at D. Draw the influence lines for the moment at C using the **basic method** and determine the maximum positive moment at C if the beam is subjected to a series of moving concentrated load as shown in Figure 11(ii).

10 marks/*markah*]

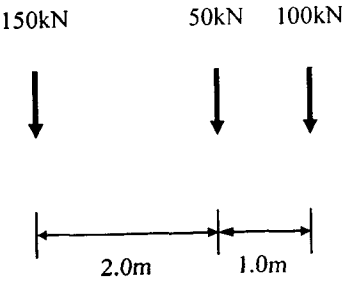
Satu rasuk dibebani dengan beban titik bersiri yang bergerak dari A ke D ditunjukkan dalam Rajah 11(i). Rasuk tersebut disokong cemat di A dan disokong rola di D. Lukiskan gambarajah garis imbas bagi momen di C menggunakan kaedah asas dan tentukan momen lentur maksimum positif di C sekiranya rasuk menanggung beban titik bersiri seperti ditunjukkan dalam Rajah 11(ii).



Figure/ *Rajah* 10



Figure/*Rajah* 11(i)



Figure/*Rajah* 11(ii)

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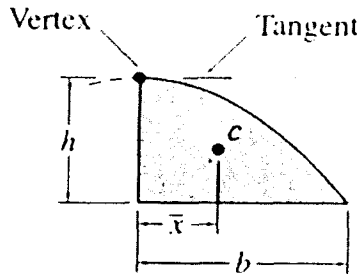
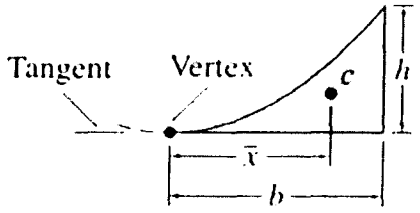
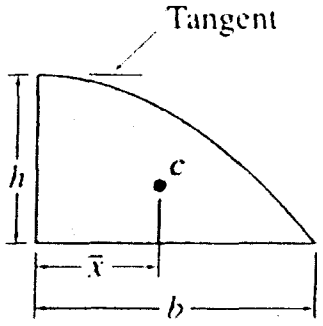
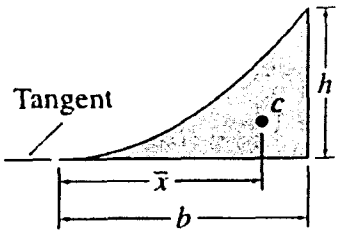
Areas and Centroids of Geometric Shapes

Shape	Area	Centroid
Semi-parabola 	$A = \frac{2bh}{3}$	$\bar{x} = \frac{3b}{8}$
Parabolic spandrel 	$A = \frac{bh}{3}$	$\bar{x} = \frac{3b}{4}$
Cubic 	$A = \frac{3bh}{4}$	$\bar{x} = \frac{2b}{5}$
Cubic spandrel 	$A = \frac{bh}{4}$	$\bar{x} = \frac{4b}{5}$