UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS TECHNOLOGIAE: *ENGINEERING : CIVIL*
SUBJECT	:	**HYDRAULICS IV**
CODE	:	**THD 411**
ASSESSMENT	:	WINTER EXAMINATION (SUPPLEMENTARY PAPER)
DATE		15 JULY 2015
DURATION	:	(SESSION 3) 15:00 - 18:00
WEIGHT	:	40:60
TOTAL MARKS	:	100

ASSESSOR	:	G.K. NKHONJERA
MODERATOR	:	PROF. F.M. ILUNGA
NUMBER OF PAGES	:	PAGES: 13 including the cover page and Annexures.

INSTRUCTIONS :

1. This paper contains 6 questions.
2. ANSWER **ALL** QUESTIONS
3. Make sure that you understand what the question requires before attempting it.
4. Any additional material is to be placed in the answer book and must indicate clearly the question number, your name, and Student number.
5. Where necessary, answers without calculations will not be considered.

ANSWER ALL QUESTIONS

QUESTION 1 [15]

1.1 In your own words, discuss the concepts of Hydraulic Jump in open channel flow hydraulics. (3)

1.2 Two objects of the same volume, one made of wood and the other made of steel, are immersed in water. It is argued that each of the two objects will be subjected to the same buoyant force. Do you agree? Explain your answer. (3)

1.3 In as far as fluid mechanics or hydraulics is concerned, state the difference between the following:

a) Dynamic viscosity and Kinematic viscosity. (2)
b) Newtonian fluid and Non-Newtonian fluid. (2)
c) Centre of Pressure and Centre of Gravity. (2)

1.4 A fluid is flowing round a 45° bend through a 110 mm diameter pipe. Assuming that there is no loss in energy across the bend, state whether there is a change in momentum or not. Explain your answer. (3)

QUESTION 2 [15]

2.1 With respect to open channel flow hydraulics, discuss the difference between the following:

a) Supercritical flow and Subcritical flow. (2)
b) Hydraulic depth and hydraulic radius. (2)

2.2 Water is flowing steadily in a 0.40-m wide rectangular open channel at a rate of 0.20 m^3/s. If the flow depth in the channel is 0.15 m,

a) Determine the flow velocity in the channel. (2)
b) State whether the flow is critical, supercritical or subcritical. (3)
c) If the character of flow were to change, determine the alternate flow depth in the channel. (2)
d) Calculate the velocity and the specific energy corresponding to the alternate depth in (c) above. (4)

QUESTION 3 [15]

3.1 It is estimated that only 10% of the volume of a floating iceberg is above the surface of the sea water. If the specific gravity of the sea water is 1.035, estimate the density of this iceberg.
(3)

3.2 The inclined face AB of the tank of **Fig. 3.1** below is a plain surface containing a triangular gate AMN, which is hinged along line MN. If the mass of the gate is 3450 kg and that the reaction force R is half way between A and M,N; determine the magnitude of this reaction force, R.
(12)

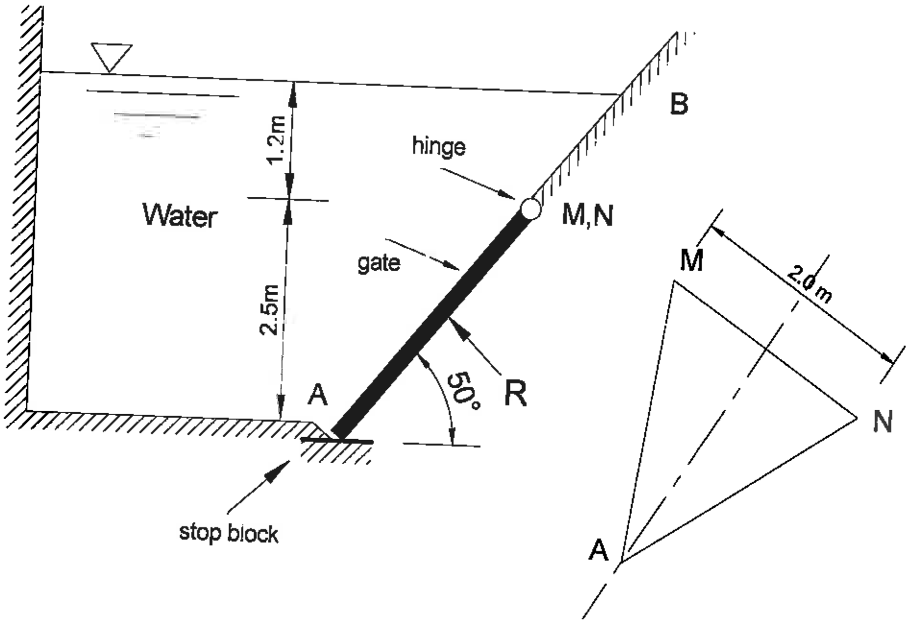

Fig. 3.1

QUESTION 4 [15]

Fig. 4.2 below shows a section of a pipe network which has two parallel pipes. The discharge in pipe CD is 50 l/s. Both pipes AB and CD have a diameter of 400 mm. The length and friction coefficient for pipe AB are 1000 m and $f = 0.004$ respectively. Likewise, the length and friction coefficient for pipe CD are 850 m and $f = 0.005$ respectively. The diameter and length of parallel pipe 1 are 200 mm and 900 m respectively while that of pipe 2 are 150 mm and 800 m respectively. The two parallel pipes are made from the same material of which the friction coefficient $f = 0.006$. With a demand of 20 l/s and 15 l/s included at junctions B and C respectively, determine the following:

a) Discharge in pipe AB. (3)
b) Discharges in pipe 1 and 2. (7)
c) Total head loss due to friction between A and D. (5)

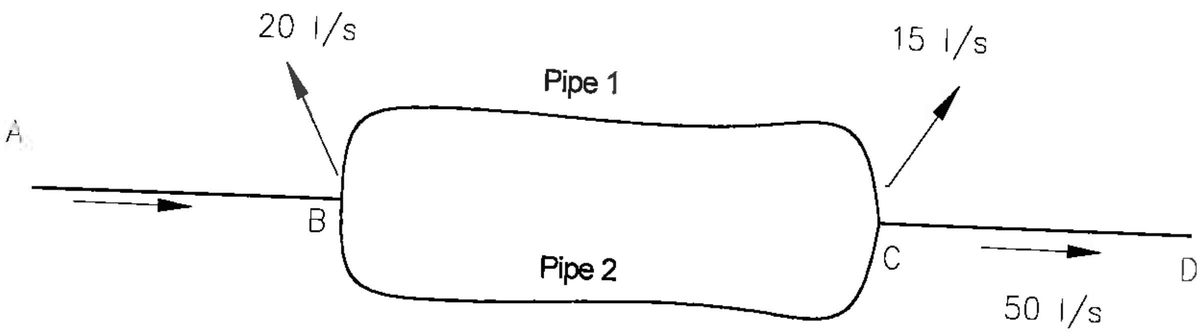

Fig. 4.2

QUESTION 5 [20]

5.1 An irrigation channel with a flow depth that is 60% of the bed width conveys 49.7 m^3/s of water to an irrigation farm. This excavated earth channel is well maintained with a Manning's coefficient, $n = 0.022$. The channel has a bed slope of 0.002 and side slope of 1:4 (V:H). Taking the flow to be uniform, determine the following:

a) Channel bed width and Normal depth. (6)
b) Specific energy in the channel. (2)

5.2 The channel shown in **Fig. 5.3** below is constructed with float-finished concrete ($n = 0.015$) and is laid on a longitudinal channel slope that falls 0.1 m per 100 m of length. The channel should be designed to carry a discharge of 15.9 m^3/s. Making use of Appendices E and F, calculate the following:

a) Normal depth of the channel. (4)
b) Velocity in the channel. (4)
c) Critical depth. (4)

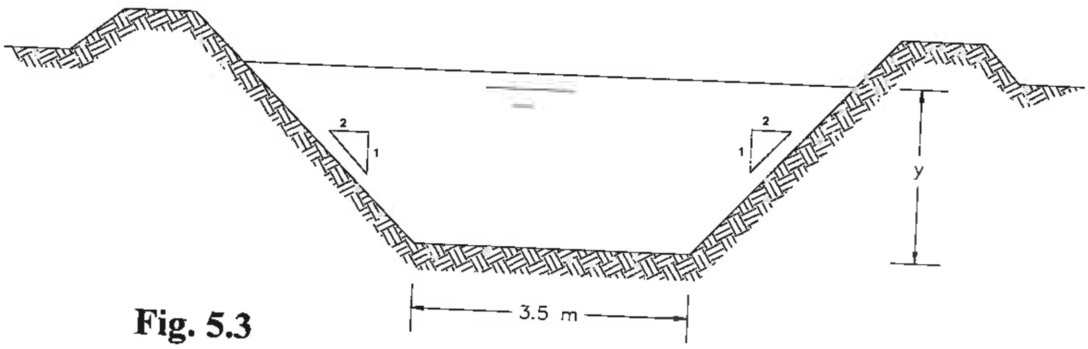

Fig. 5.3

QUESTION 6 [20]

Water is to be pumped from a reservoir to a tank way up the hill as shown in **Fig. 6.4**. A quick preliminary site inspection shows that the only place fit for a pump station is somewhere 2.5 m above the water level in the reservoir. The client already has a centrifugal pump for which you are to test its suitability for this job. When running at a constant speed of 1300 rpm this pump gave the following characteristics as tabled below. The only pipe size available for the job is a 150 mm pipe which has a roughness size, $k = 0.33$ *mm*.

Discharge (L/s)	140.00	127.00	111.00	86.00	57.00	30.00	0.00
Head (m)		24.00	39.00	57.00	69.00	79.00	84.00
NPSH required (m)		6.80	5.30	4.50	3.10	2.60	2.00
Input Power (kW)	90.00	85.00	78.00	67.00	49.00	39.00	25.00

a) Determine the head, discharge and power input at which the pump is operating. (12)

b) Calculate the efficiency at which the pump is operating. (1)

c) If the local atmospheric pressure is 76 cm of mercury (SG =13.6) and vapour pressure is 7.5 kPa, calculate the NPSH available. (3)

d) For this pump, if the speed of the pump was to be increased to 1600 rpm, what do you think would be the:

   i) Discharge. (2)

   ii) Head. (2)

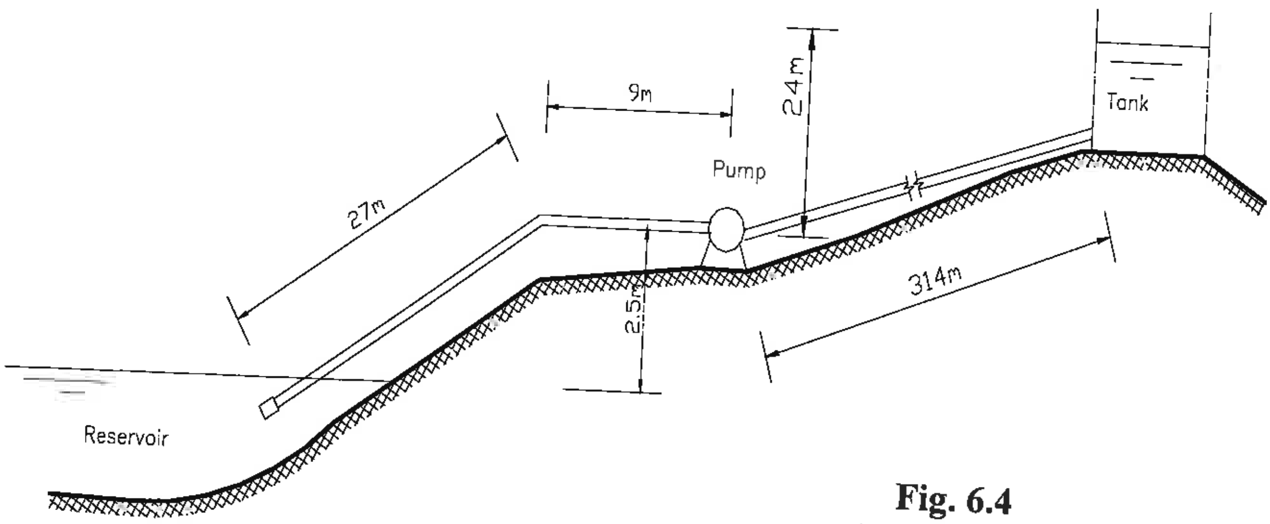

Fig. 6.4
(Not to scale)

WELCOME BACK FROM YOUR HOLIDAY!!

APPENDIX A

FORMULAS

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OPEN CHANNEL FORMULAS

$V = \frac{1}{n} R^{2/3} S^{1/2}$

$V = C R^{1/2} S^{1/2}$

Froude number:

$N_F = \frac{V}{\sqrt{gD}}$

Specific energy:

$E = y + \frac{V^2}{2g}$

Critical conditions (general):

$\frac{Q^2 T}{A_c^{\,3} g} = 1$

Critical conditions (rectangular):

$\frac{Q^2}{T^2 D_c^{\,3} g} = 1$

Hydraulic jump:

$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1 + 8F_{r1}^2} - 1\right)$

$h_L = \frac{(y_2 - y_1)^3}{4 y_1 y_2}$

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PUMP HYRAULICS FORMULAS

$h_f = \frac{4 f L V^2}{2gD}$

$h_f = \frac{f L Q^2}{3.03 D^5}$

$h_m = K \frac{V^2}{2g}$

$P = \rho g Q H$

$\eta = \frac{P_{output}}{P_{input}}$

$NPSH_A = H_{atm} \pm H_S - H_f - H_v - H_{vap}$

$H_{sys} = H_s + H_f$

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HYDROSTATICS

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HYDRODYNAMICS

Energy Equation:

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$D = \bar{y} + \frac{I}{A\bar{y}}$ $P = \rho g h$ $F = \bar{P} A$ Buoyancy: $BM = \frac{I}{\forall}$	$\frac{P_A}{\rho g} + \frac{V_A}{2g} + Z_A = \frac{P_B}{\rho g} + \frac{V_B}{2g} + Z_B + h_L$

Formula	Flow Conditions	Pipe Conditions	Reynolds Number
$f = \frac{16}{\mathrm{Re}}$	Laminar	Smooth	$\mathrm{Re} < 2000$
$f = \frac{0.0791}{\mathrm{Re}^{1/4}}$	Turbulent	Smooth	$4 \times 10^4 < \mathrm{Re} < 10^5$
$\frac{1}{\sqrt{4f}} = 2.0 \log_{10}\left(\mathrm{Re}\sqrt{4f}\right) - 8.0$	Turbulent	Smooth	$5 \times 10^5 < \mathrm{Re} < 4 \times 10^7$
$\frac{1}{\sqrt{4f}} = 2.0 \log_{10}\left(R/k\right) + 1.74$ Or $\frac{1}{\sqrt{4f}} = 2.0 \log_{10}\left(3.7\, D/k\right)$	Turbulent	Rough	$\mathrm{Re} > 4000$

$h_f = \frac{4fLV^2}{2gD}$; $\mathrm{Re} = \frac{\rho V D}{\mu}$

Re = Reynolds Number
k = roughness size
R = radius of pipe. And D = diameter of pipe.
V = average velocity in the pipe.
μ = dynamic viscosity.

Pump Characteristic Curves

PUMP SELECTION USING CHARACTERISTIC CURVES

Design Discharge, Q =

Operating Head, H = __________

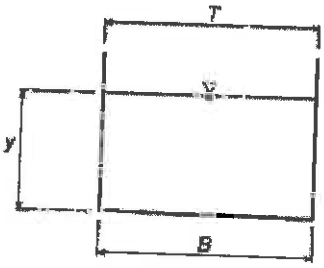
Efficiency, η = __________

Power Input P = __________

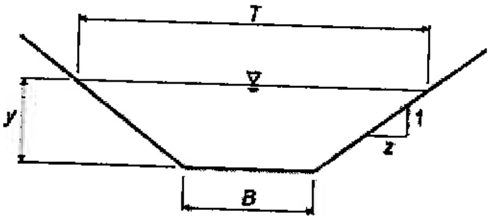
$NPSH_R$ = __________

APPENDIX C

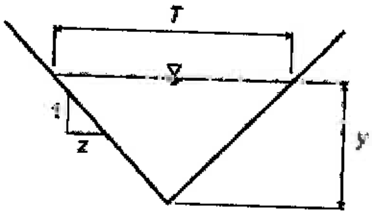
OPEN CHANNEL CROSS SECTIONS



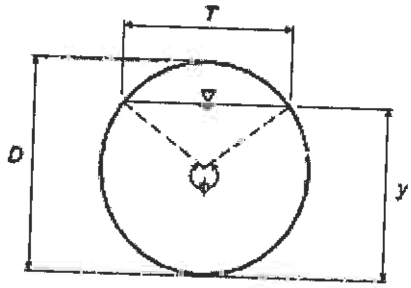
Rectangular



Trapezoidal



Triangular

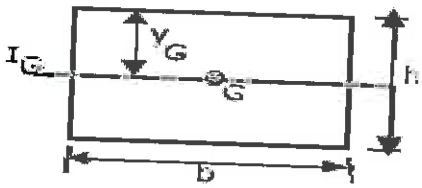
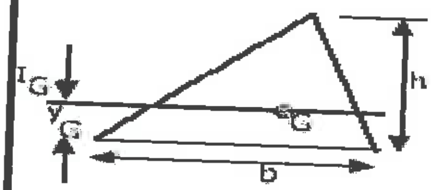
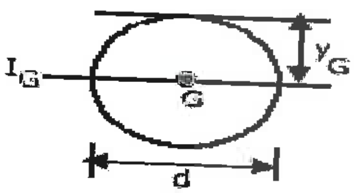
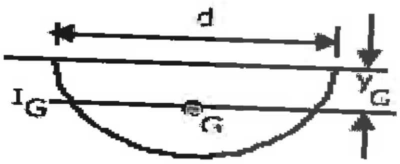
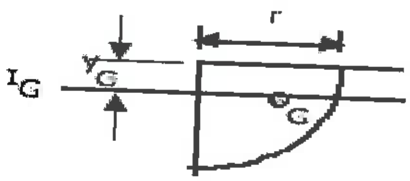


Circular

Channel Shape	***Area, A***	***Wetted Perimeter, P***	***Hydraulic Radius, R***	***Top Width, T***
Rectangular	By	$B+2y$	$\frac{By}{B+2y}$	B
Trapezoidal	$By+zy^2$	$B+2y\sqrt{1+z^2}$	$\frac{By+zy^2}{B+2y\sqrt{1+z^2}}$	$B+2zy$
Triangular	zy^2	$2y\sqrt{1+z^2}$	$\frac{zy}{2\sqrt{1+z^2}}$	$2zy$
Circular *(ϕ in radians)*	$\frac{D^2(\phi-\sin\phi)}{8}$	$\frac{D\phi}{2}$	$\frac{D}{4}\left(1-\frac{\sin\phi}{\phi}\right)$	$D\frac{\sin\phi}{2}$

APPENDIX D

GEOMETRICAL PROPERTIES OF COMMON FIGURES

	AREA	CENTROID	SECOND MOMENT OF AREA, I_G
Rectangle 	bh	$y_G = \frac{h}{2}$	$\frac{bh^3}{12}$
Triangle 	$\frac{bh}{2}$	$y_G = \frac{h}{3}$	$\frac{bh^3}{36}$
Circle 	$\frac{\pi d^2}{4}$	$y_G = \frac{d}{2}$	$\frac{\pi d^4}{64}$
Semicircle 	$\frac{\pi d^2}{8}$	$y_G = \frac{2d}{3\pi}$	0.0069 $0.069\ d^4$
Quarter circle 	$\frac{\pi r^2}{4}$	$y_G = \frac{4r}{3\pi}$	$0.553\ r^4$

APPENDIX E

OPEN CHANNEL DESIGN, NORMAL DEPTH

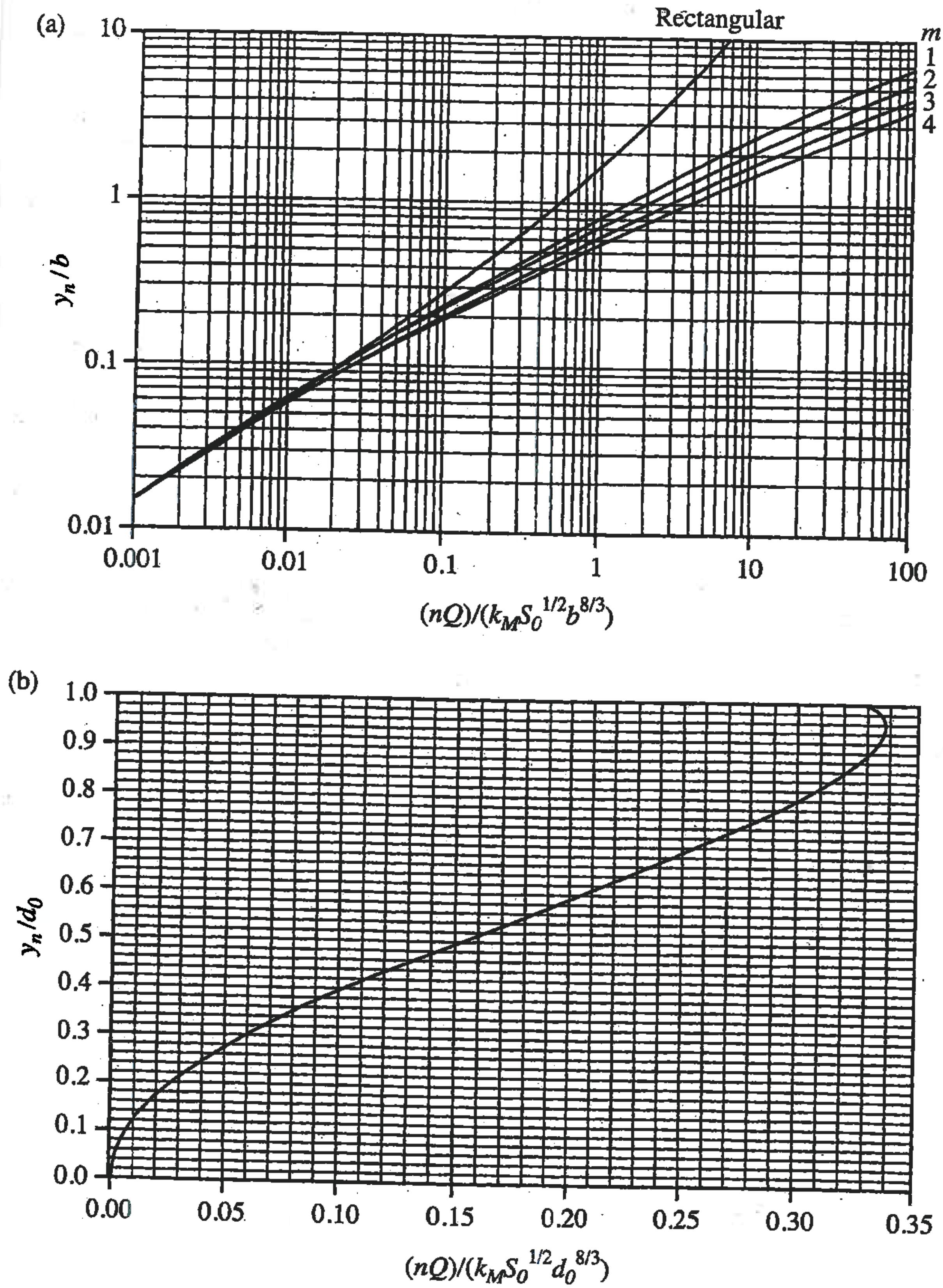


Figure 6.4 Normal depth solution procedure: (a) trapezoidal channels (m = side slope) and (b) circular channels (d_0 = diameter)

APPENDIX F

OPEN CHANNEL DESIGN, CRITICAL DEPTH

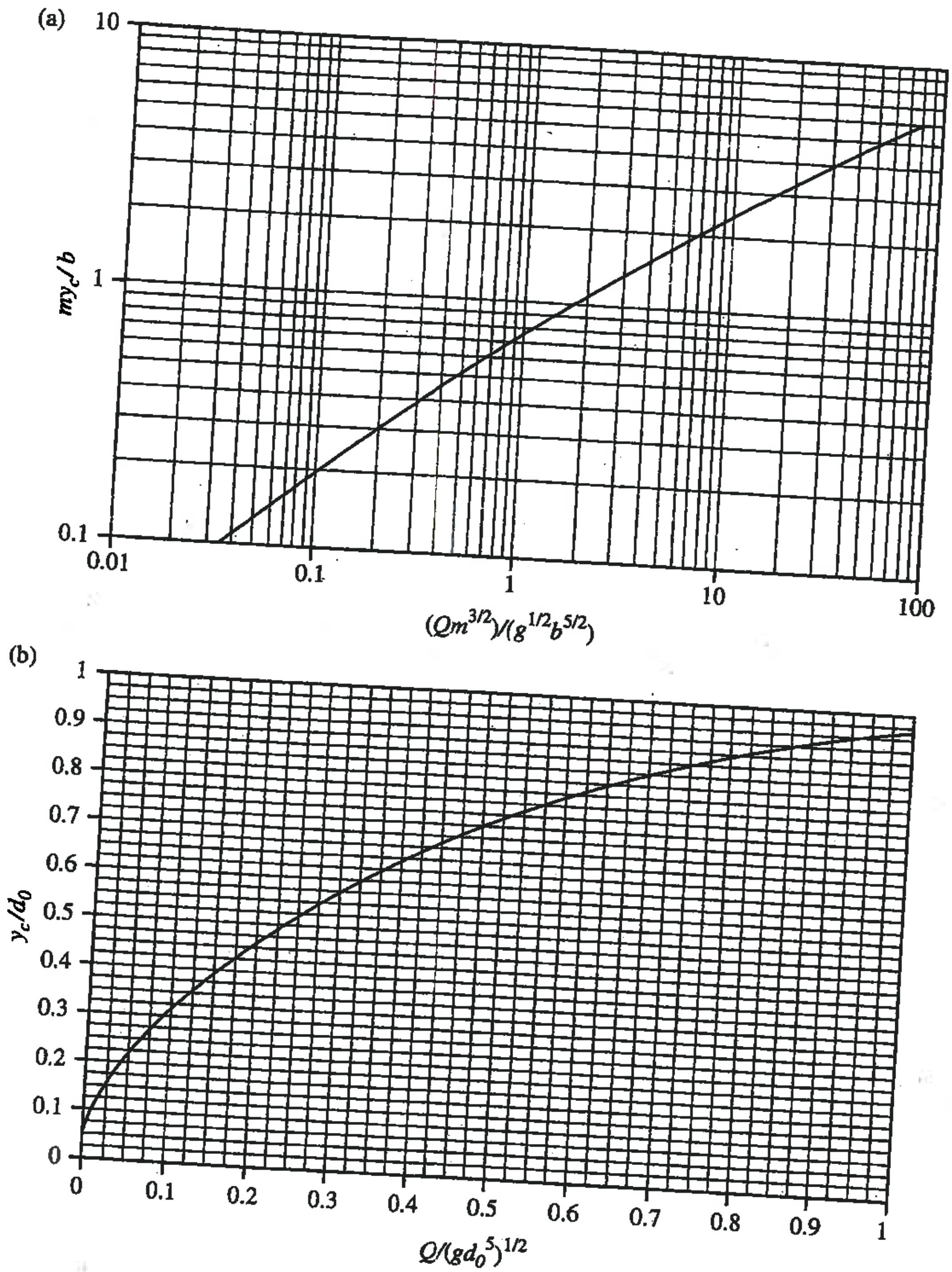


Figure 6.9 Critical depth solution procedure: (a) trapezoidal channels and (b) circular channels