International Hydrographic Review, Monaco, LXIII (1), January 1986

TIDE GUIDE

(A graphical method of estimating height of tide at a given time or the time at which tide attains a required height in water areas subject to semidiurnal tides) (*)

by Captain Madhav JOSHI (**)

1. — SUMMARY

This paper first describes and examines briefly various methods available to a navigator, port official or operator, etc., for determining height of tide at a given time and/or the time at which the tide will attain a given (required) height in water areas which are subject to semidiurnal tides. It then introduces a new graphical method for determining these two variables (height or time). Finally, it compares the results obtained by these methods and shows that the new method gives results within acceptable limits. Because of the complete absence of calculations and ease of use, this new method should be readily acceptable to users.

2. — INTRODUCTION

If ships' navigators, port officials, operators and users, etc., in channels, port approaches and ports (where tides are semidiurnal) wish to determine :

(a) Height of tide above chart datum (C.D.) at a certain (given) time, and/or

(b) Time when the tide will rise or fall to a certain (required) height above chart datum

they can make use of one of the following methods to solve such problems :

(i) Rule of thumb method used by pilots in some ports.

(ii) Admiralty Tide Tables method, using 'factor' found from the diagrams given in the tide tables.

(*) *Editor's note.* — National Hydrographers may apply to the author for permission to reproduce the graphics in official tide tables.

(**) Dock Master, Bombay Port Trust, Bombay, India.

(iii) Correction to low water/high water levels and times found by the formula : correction = 1/2 range (1 − cos θ).

(iv) By solving the equation : $ht = h_o + R/2 \cos\left(\frac{t\pi}{d}\right)$.

(v) Ready reckoner tables such as those given in Brown's Nautical Almanac or Table 3, Appendix L, given in the American Practical Navigator.

(vi) Graphical method as illustrated in the American Practical Navigator (Bowditch) Article 1206.

Examination of these various methods (shown in Annex I) shows :

(i) Though method (i) is not widely publicised, it has one main advantage in that it does not require trigonometrical ratios in calculations. Only simple arithmetical calculations and linear interpolations are necessary. If worked to two decimals, sufficient accuracy is possible. Though the total number of steps is large, these are quite simple.

(ii) Method (ii) also does not involve use of trigonometrical ratios, but is a combined method using simple calculations and a 'factor' obtained from the diagrams given in Admiralty Tide Tables (A.T.T.); some care is necessary in interpolating from the diagrams (factor or interval) as the duration curves are for intervals of 30 minutes (5 to 7 hours' duration) and the vertical lines for intervals before and after high water are 20 minutes apart. The number of steps is moderate.

(iii) and (iv). In methods (iii) and (iv), as the formulae indicate, one has to use trigonometrical ratios (functions cosine, haversine); hence, the availability of trigonometrical tables or calculators is presupposed. Calculations are more difficult than in methods (i) and (ii).

(v) In method (v), the tables referred to also give a correction or factor and the calculations are similar to those in method (ii). Interpolations are necessary.

(vi) Method (vi) is almost completely a graphical method and the only calculation necessary is applying a correction to low (high) water heights or to the times of low (high) water found from curves.

A certain amount of care is necessary, as the correction curves for heights are 0.5 ft apart and the 'intervals' from low water curves are 20 min apart. The range scale is 1 ft apart and the duration scale is 20 min apart. Therefore, accuracy will depend upon the ability to measure and interpolate between curves and scales.

All the above methods, apart from the ease or difficulty of calculations, the use of trigonometrical ratios and the interpolation involved, require a separate calculation for a different variable (time or height) during the given tidal situation. That is to say, only one variable can be solved in one calculation. These methods also do not give a visual display (for purposes of comparison), nor do they indicate the behaviour of the tide during complete duration and range for the period in question.

3. — NEW GRAPHICAL METHOD 'TIDE GUIDE' INTRODUCED

(i) The author of this paper attempted to design a method which would eliminate calculations altogether, have the advantages of a graphical method and, at the same time, be easy to understand and use. The result is the Tide Guide which is being introduced in this section. The Tide Guide is essentially a set of curves depicting rise (or fall) of tide in 6 hours 12 minutes (standard) duration. (As in semidiurnal tides, each successive high water occurs 12 h 25 min later). It is advisable to use the Tide Guide under the same conditions as those applicable in the A.T.T. method, namely a duration of 5 to 7 hours and semidiurnal tides.

(ii) Description of 'Tide Guide' [see Annex II(i)]
The Tide Guide is divided into two (upper and lower) halves by the horizontal lines HH′ and TT′. These two lines form the horizontal axis for the upper and lower halves respectively. (The space between HH′ and TT′ is used to mark the standard duration scale of 6 hours and 12 minutes. The standard scale is divided into intervals 15 min apart. Against the standard duration scale are plotted the heights of tides for different ranges using the formula of the third method) : $1/2\ R\,(1 - \cos\theta)$. Heights of tide are measured on the vertical axis represented by vertical lines H′R′ in metres on the right and HR on the left in feet. These are also range and height scales. So various tidal range curves (from 0.25 m to 6.0 m) are plotted time vs height. The horizontal scale RR′ on top of the diagram is the reverse of the HH′ scale (on the right) and 6 hours 12 min to denote falling tide from high water to low water. For the lower half of the Tide Guide, TT′ is the horizontal axis (similar to HH′) depicting standard tidal duration of 6 hours 12 min. Starting from T and T′ and extending vertically downwards are the lines TD and T′D′ which are the time scales representing the actual duration of tides and intervals from low (high) water times. The scale is divided into intervals of 5 minutes. Thus along TD or T′D′ we can mark off the actual duration of flood or ebb tides, the interval from high or low water times, etc. (scale TD is used for ebb tide, on the left, and scale T′D′, on the right, is used for flood tide). For solving problems during flood tide, a diagonal line starting from T (left hand, upper corner of the lower half) towards the appropriate duration point on the vertical scale T′D′ is to be drawn. Conversely, during ebb tide situations, a diagonal line from T′ running left and downwards to meet the appropriate point of ebb duration on the vertical scale TD is to be drawn.

(iii) Use of Tide Guide — an illustrated example [see Annex II(ii)]

At Bombay, on 29th July 1980, during the morning flood tide, it is required to find :

(a) At and after what time will there be 2.13 m (7.0 ft) of water above C.D.

(b) What will be the height of water above C.D. at 11 h 45.

a) To find the time for a tidal height of 2.13 m.

Step 1 : From tide tables take the data for 29th July 1980 for Bombay, a.m. flood tide and enter these particulars in the box in the left hand upper corner of the Tide Guide. This gives the duration of 6 h 49 min and range 4.45 m or 14.59 ft.

Step 2 : In the upper half of the Tide Guide there are various curves showing rise or fall of tides of different ranges (0.25 m to 6.0 m, 0.25 m apart). In the present example, since the range is 4.45 m, the range curve of 4.5 m is the nearest curve, so shade lightly along and just below this curve to identify the curve and the area which is to be used.

Step 3 : In the right hand open column space (to the right of H'R') near 0, write down the actual tide level at low water, i.e. 0.26 m and every 1 m apart, write down 1.26 (against 1.0 m of the scale) 2.26 m, 3.26, etc., until 4.76 m is reached against 4.5 m range curve.

Step 4 : Since we have to calculate for a flood tide situation, draw a diagonal line for given duration, i.e. 6 h 49 min. From the left hand upper corner (T), draw a diagonal line to meet a point showing 6 h 49 min on the vertical time scale T'D'.

Step 5 : Since we have to ascertain height/time during flood tide in this example, draw a diagonal for given duration, i.e. 6 h 49 min. From the left hand upper corner (T), draw a diagonal line to meet a point showing 6 h 49 min on the vertical time scale T'D'.

Step 6 : At point 0 (T') of the duration scale in the vacant column, write down the actual time of low water (6 h 29 in this case) and at hourly intervals write down the appropriate time, i.e. 0729, 0829, etc., until 1329 against 7.00 hours of the scale is reached.

Step 7 : First we shall find the time for the required height (2.13 m or 7.0 ft). Along H'R' against the range scale, 2 m corresponds to an actual height of 2.26 m, and one division scale below that would be 2.16 actual. As the height in question is 2.13 m, from a point just below 2.16 actual height (point A), draw a horizontal line to the left till it meets a point just below 4.5 m range curve (in shaded area). Call this point B.

Step 8 : From this point B, draw a vertical line downwards till it intersects the diagonal line in the lower (duration) half at point C. From point C, draw a horizontal line to the right to meet the duration (time) scale at point P. Point P is approximately 3 h 02 min after low water time, that is at 9 h 31. Therefore, the required answer (time) is : at and after 9 h 31 there will be 2.13 m or 7.0 ft water above C.D.

(b) To find the height of tide at 11.45 hours.

Steps 1 to 6 as above.

Step 7 : Since low water is at 6 h 29 and height is required at 11 h 45, we have to find the height of water 5 h 16 min after low water. So choose a point I on the duration scale (right hand scale) corresponding to 11 h 45 actual time.

Step 8 : From point I, draw a horizontal line to the left to meet the diagonal line at point 'J'. From point 'J', draw a vertical line upwards to meet at a point just below the 4.5 m range curve (shaded area). Call this point 'K'. From point 'K', draw a horizontal line to the right to meet height scale (meters) at point 'L'. It meets the scale one division below the 4.0 m mark of the scale corresponding to 4.16 of the actual scale. Therefore, 4.16 is the predicted height above C.D. at 11 h 45.

5. — CONCLUSION

In annex III, a comparison is made of the results obtained by using various methods described in part 2 of this paper. Eight examples were worked out for Neap, Spring flood and ebb tides. From the Bombay Port Trust's Engineering Dept., hourly actual and predicted tidal levels were obtained for further comparison. It can be seen from the comparison that the Tide Guide provides results accurate enough for practical use without any calculations or interpolations. This method also has an advantage in that it provides a visual comparison between various ranges and durations (which could give a rough indication of the strength of tidal currents (streams) for tides of different ranges and durations). It is therefore submitted that the Tide Guide method can be put to practical use by its inclusion in publications like Admiralty, or American Tide Tables, or it can be used as a separate sheet for shipboard or shore use. As the Tide Guide can be printed on paper, plastic or perspex sheets, or on photographic paper of suitable thickness, an ordinary pencil or a glass pencil along with parallel rulers and erasers are all that is needed for its repeated use.

Note : An application has been made to obtain copyright under the Indian Copyrights act for this diagram Tide Guide. In the meantime, the author of this paper will be pleased to answer any queries or give clarification on the use of this method.

TIDE GUIDE — ANNEX I (i)

Method (i) — Rule of thumb

Example illustrated :

At Bombay, on 29th July 1980, during the morning flood tide, it is required to find :

(a) At and after what time will there be 2.13 m (7.0 ft) of water above chart datum.

(b) What the height of water above C.D. will be at 1145 h.

Step 1 :

From tide tables take times of high and low water nearer the times in question to obtain the duration of flood or ebb tide.

29th July 1980 at Bombay

L.W.	0629 h	Ht	0.26 m	0.852 ft
H.W.	1318 h		4.71 m	15.448 ft
Duration	0649 h	Range :	4.45 m	14.596 ft

Step 2 :

Divide the range (in meters or feet) into 16 equal parts (R/16). Also divide the duration (d) into 6 equal parts (d/6). This can be expressed in hours and minutes or minutes. d/6 is the tidal hour.

$$R/16 = \frac{4.45}{16} = 0.278 \text{ m}$$

or

$$\frac{14.596}{16} = 0.912 \text{ ft}$$

$$d/6 = \frac{06 \text{ h } 49 \text{ min}}{6} = \frac{409 \text{ min}}{6}$$

$$= 1 \text{ h } 08.1 \text{ min or } 68.1 \text{ min}$$

Step 3 :

Tide rises (or falls) in the following proportion :

— At end of 1st tidal hour it rises (or falls) R/16 $\frac{R}{16}$

— At end of 2nd tidal hour it rises (falls) further 3/16th R (total 4/16th R)

L.W. at	0629	Ht	0.26 m	0.852 ft
	+0108		+0.278	+ 0.912
	0737		0.538	0.764
	+0108		+0.834	+ 2.736
	0845		1.372	4.50

— At end of 3rd tidal hour it rises (falls) further 4/16th (total 1/2 R)	+0108		+1.112	+ 3.649
	0953		2.484	8.149
— At end of 4th tidal hour it rises (falls) further 4/16th (total 3/4 R)	+0108		+1.112	+ 3.649
	1101		3.596	11.798
— At end of 5th tidal hour it rises (falls) further 3/16th (total 15/16th R)	+0108		+0.834	+ 2.736
	1209		4.430	14.534
— At end of 6th tidal hour it rises (falls) further 1/16th (total = range)	+0108		0.278	0.912
H.W. at	1317	Ht	4.708 m	15.446 ft.

Thus we have heights of tide at an interval of one tidal hour (duration/6) from time of low or high water to next high or low water respectively.

Step 4 :

From the above data, by linear interpolation we can find either the height of tide at a given time or the time the tide will attain a required height.

(a) At and after what time will there be 2.134 m or 7.0 ft water above C.D. (rise of tide) ?

Ht reqd.	2.134 m	7.0 ft
Ht at 0845	1.372 m	4.5 ft
Further rise	0.76 m	or 2.5 ft reqd.
For 1.122 m or 3.649 ft		68 minutes
for 0.762 m or 2.5 ft		?

46.5 minutes after 0845 h, i.e. at 0931 h approximately.

(b) What will the height of tide be at 1145 h ?

At 1101 height is 3.596 m or 11.798 ft

reqd. 1145 h

44 min after 1101 h

In 68 min rise 0.834 m or 2.736 ft

In 44 min ?

0.0539 m or 1.77 ft

+3.596 m 11.798 ft

at 1145 h : 4.13 m or 13.568 ft approx.

***

ANNEX I (ii)

Method (ii) : Admiralty Tide Tables (Vol. II & III)
'Factor' obtained from diagrams in the tables.

TIDAL PREDICTION FORM

Standard Port : Bombay — Time or height required : (*a*) 2.13 m (*b*) 1145 h
Secondary Port : .... — Dated 29th July 1980 — Time zone : + 0530 h

	Time		Height		Time		Height	
Standard Port	H.W.	L.W.	H.W.	L.W.	H.W.	L.W.	H.W.	L.W.
	1 1318	2 0629	3 4.71	4 0.26	1 1318	2 0629	3 4.71	4 0.26
Seasonal change in M.L.	− Std. Port 5 − + Second. Port 6 −							
Difference	7 −	8 −	9 −	10 −	7 −	8 −	9 −	10 −
Secondary Port	11 1318	12 0629	13 4.71	14 0.26	11 1318	12 0629	13 4.71	14 0.26
Duration	15 0649	16 a	Range	4.45	15 0649	16 a	Range	4.45
* Springs /	Neaps / Intermediate							
Start height at given time								
	Reqd. time		17 : 1145		Reqd. time		17 : 0935	
	Time H.W.		18 : 1318		Time H.W.		18 : 1318	
	Interval		19 : − 0133		Interval		19 : + 0343	
	Factor		20 : 0.88		Factor		20 : 0.42	
	Rise		21 : 3.916		Rise		21 : 1.874	
	Height L.W.		22 : 0.260		Height L.W.		22 : 0.260	
	Height reqd.		23 : 4.176		Height reqd.		23 : 2.134	

Start :
Time for given height

20 : Factor is obtained from interpolation of appropriate curve entered with interval 19.

21 : Rise = factor × range.

19 : Interval is obtained from interpolation of appropriate curve entered with factor 20.

20 : $\text{Factor} = \dfrac{\text{rise}}{\text{range}}$

ANNEX I (iii)

Method (iii) : Correction $= \frac{1}{2} R (1 - \cos\theta)$

Step 1 :

From tide tables take times and heights of high water and low water nearer the times in question to obtain duration and range of flood or ebb tide.

Bombay, 29th July 1980 a.m. flood

L.W.	0629	0.26 m	0.852 ft
H.W.	1318	4.71 m	15.448 ft
Duration : 0649		Range : 4.45 m	
		or	14.596 ft

Step 2 :

From range and duration find 1/2 range and 1/2 duration.

1/2 duration = 0324.5; 1/2 range = 2.225 m
or 8.150 ft

Step 3 :

Example (a) :

Required time at and after which tide will rise 2.134 m (7.0 ft) above C.D.

Height required	2.13 m
L.W. ht	0.260 m
correction =	1.87 m

Formula :

$$\text{correction} = \frac{1}{2} R (1 - \cos\theta)$$

$$1.874 = \frac{1}{2} R (1 - \cos\theta)$$

therefore $\theta = 80.92^\circ$.

Further solving,

for 180° 409 min
for 80.92° ?

Answer is 3 h 04 min after L.W. that is at 0933 h.

Example (b) :

To find height of tide above C.D. at 1145 h.

Height required at	1145 h
H.W. at	1318 h
Interval from H.W.	1 h 33 min
or	93 min.

For 409 min .... 180°
For 93 min .... ?
93 min = 40.92° = θ.

Solving correction

$$= \frac{1}{2} R (1 - \cos\theta)$$

Correction =	1.681 m
+ ht at 1/2 tide :	2.485 m
	4.166 m

Height at 1145 h will be 4.166 m.

ANNEX I (iv)

Method (iv) : Formula $H_t = H_o + \frac{range}{2}\cos\left(\frac{t\pi}{d}\right)$

Where H_t = height required (or available)
H_o = average height (height at low water + 1/2 range)
t = interval in hours (and decimals) after (before) high water
d = duration of flood/ebb.

Example :

At Bombay, on 29th July 1980, during the morning flood tide it is required to find :

(a) at and after what time there will be 2.13 m (7.0 ft) of water above chart datum (C.D.),

(b) what the height of water above C.D. will be at 1145 h.

Step 1 :

From tide tables take out times and heights of high water and low water nearer the times in question to obtain duration (d) and range (R) of flood (or ebb) tide.

At Bombay, 29th July 1980 a.m. flood

L.W. at	0629	Ht 0.26 m	0.852 ft
H.W. at	1318	4.71 m	15.448 ft

∴ duration 6 h 49′ range = 4.45 m or 14.596 ft

i.e. d = 6.8166 1/2 R = 2.225 m

Step 2 :

From range find 1/2 range and add height at low water. This gives Ho.

R = 4.45 ∴ 1/2 R = 2.225 m
Ht at low water = 0.26 m
∴ Ho = 2.485 m

Step 3 :

Example (a) :

Required time at and after which tide will rise 2.134 m (7.0 ft) above C.D.

Ht = 2.134 m

∴ Required to find t in formula

$$Ht = Ho + \frac{range}{2}\cos\left(\frac{t\pi}{d}\right)$$

Example (b) :

Required to find the height of tide above C.D. at 1145 h

t = time before (after) high water

∴ t = 1318 − 1145 = 01 h 33 min

t = 1.55.

Required to find Ht in formula.

Step 4 :

To solve the above equation to find t — using scientific calculator (use Radian mode).

$$Ht = Ho + \frac{R}{2}\cos\left(\frac{t\pi}{d}\right)$$

$$\therefore 2.134 = 2.485 + 2.225\cos\frac{(t\pi)}{6.8116}$$

$$\therefore 2.134 - 2.485 = 2.225\cos\frac{(t\pi l)}{(6.8166)}$$

$$\therefore \frac{-0.351}{2.225} = \cos\frac{(t\pi)}{(6.8166)}$$

To solve the above equation to find Ht

$$Ht = Ho + \frac{range}{2}\cos\left(\frac{t\pi}{d}\right)$$

$$= 2.485 + 2.225\cos\frac{(-1.55\times\pi)}{(6.8166)}$$

$$\left[\therefore \cos\frac{(-1.55\times\pi)}{6.8166} = 0.7555\ 1631\right]$$

$\therefore -0.157752808 = \cos \frac{(t\pi)}{(6.8166)}$

Inverse cos of $-$ 0.157752808

= 1.7292109

$\therefore 1.7292109 = \frac{t\pi}{6.8166}$

$\therefore t = \frac{1.7292109}{x} \times 6.8166$

$\therefore$ t = 3.75 = 3 h 45 min before high water

i.e. 1318 $-$ 3 h 45 = 9 h 33 min.

$\therefore$ Tide will rise 2.134 m above C.D. after 9 h 33 min.

Originally this formula in its general form was :

$$H_t = Ho + \frac{range}{2} \cos \left(\frac{t\pi}{6}\right)$$

$\therefore$ Ht = 2.485 + 2.225 (0.75551631)

= 2.485 + 1.6810

= 4.166

$\therefore$ At 1145 h tide will rise 4.166 m above C.D.

***

ANNEXE I (v)

Method (v) : Tables given in the 'American Practical Navigator'
(Appendix L, Table 3)

(Since the tables are for ranges in feet, in the given example all heights are converted from meters into feet and vice versa as necessary).

Example (A) :

Find the time when the height of tide will be 2.13 m (7.0 ft) above chart datum at Bombay on 29th July 1980 (a.m. flood tide).

Step 1 :

From the tide tables get the times of low and high water and the respective heights to get the duration and the range.

L.W. at 0629 h Ht. 0.26 m = 0.852 ft
H.W. at 1318 h Ht. 4.71 m = 15.44 ft

Duration : 06 h 49 min Range : 14.59 ft

Step 2 :

Since the height required is 7 ft and

Example (B) :

Required height of water at 1145 h.

Step 1 :

As in example A.

Step 2 :

Since H.W. is at 1328 h, which is nearer to height at low water is 0.85 ft, rise of tide 6.15 ft above low water level is required. This is correction to height.

Step 3 :

Enter the lower part of table 3 with a range of 14.5 ft and follow horizontally until values nearer to 6.15 are reached (5.7 in one column and 6.5 in the next). Follow vertically until in the upper half of the table a value of 2 h 53 min is reached against a duration of 6 h 40 min, and a value of 3 h 02 min is reached against a duration of 7 h. Since the actual duration is 6 h 49 min, the value will be between 2 h 53 min and 3 h 02 min i.e. 2 h 57 min.

Step 4 :

Similarly, following vertically above 6.5 correction to height for 6 h 40 min — 3 h 07 min and for 7 h — 3 h 16 min values found. For an actual duration of 6 h 49 min, 3 h 11 min will be the required value.

Step 5 :

Further interpolating, for 6.1 correction to height, time from the nearest low water will be 3 h 04 min.

Step 6 :

Adding this to low water time 0629 + 0304 = 0933 h is the required answer.

the time in question, therefore time from H.W. is 1318 − 1145 = 0133.

Step 3 :

The duration of tide is 6 h 49 min (nearest approximation 6 h 50 min). In the upper half of the table from durations 6 h 40 min and 7 h 00 min, follow horizontally until values of 1 h 20 min and 1 h 24 min are reached. Value for 6 h 50 min will be 1 h 22 min.

Step 4 :

Similarly, in the next column values are 1 h 33 min and 1 h 38 min. Therefore, for 6 h 50 min, the value will be 1 h 35 min.

Step 5 :

Following vertically to the lower part of the table against the range of 14.5 ft, we get correction of 1.4 ft for 1 h 22 min and 1.9 for 1 h 35 min. For 1 h 33 min, correction is 1.8 ft.

Step 6 :

Height at High Water is 15.448 minus correction of 1.8; we get a height of 13.65 as the answer (4.16 m).

ANNEXE I (vi)

Graphical Method given in the American Practical Navigator.

(Since the graphical method is for heights in feet, in the given example all heights are converted from meters into feet and vice versa as necessary).

Example (A) :

To find the time at which the tide will rise to 2.13 m (7.0 feet) above chart datum at Bombay on 29th July 1980 a.m. flood tide.

Example (B) :

Required height of water at 1145 h.

Step 1 :

From tide tables get the times and heights of low and high water to get the duration and the range of a.m. flood tide.

L.W. at	0629	Ht	0.26 m	=	0.85 ft
H.W. at	1318	Ht	4.71 m	=	15.44 ft

Duration : 06 h 49 min Range : 14.59 ft

Step 2 :

Height at low water is 0.85 ft and the required height is 7.0 ft, therefore correction to low water height is 6.15 ft. Enter the lower graph and find the intersection of the vertical line representing 14.6 ft (interpolated between 14 ft and 15 ft range lines) and the curve representing 6.1 correction (just above 6.0 ft curve in white). Call this point of intersection point A.

Step 3 :

From this point (A) follow horizontally to the sine curve (point B).

Step 4 :

From this point (B) follow vertically to the horizontal line in the upper figure representing the duration of rise 6 h 49 min (this will be a line between the 6 h 40 min line and 7 h line). This is point C.

Step 5 :

Point C is just to the right of the curve representing the interval in hours from the low water 3-hour curve. Therefore, the interval is approximately 3 h 3 min after low water.

Step 6 :

This is to be added to the time of low water : 0629 + 0303 = 0932, which will be the time when the tide will rise 7.0 feet or 2.13 m above chart datum.

Step 1 :

As in example A.

Step 2 :

Enter the upper graph with the duration of rise or fall of tide. (In this case the duration of rise is 6 h 49 min, say 6 h 50 min). This is represented by a horizontal line (between lines of 6 h 40 min and 7 h duration).

Step 3 :

Find the intersection of this line and the curve representing the interval from the nearest low water. (In this case 1145 − 0629 = 0516). Call this point A.

Step 4 :

Find the intersection of this line and the curve representing the interval from the nearest low water. (In this case 1145 − 0629 = 0516). Call this point B.

Step 5 :

From point B follow horizontally to the vertical line representing the range of tide. (Range in this case is 14.6 feet). This is point C.

Step 6 :

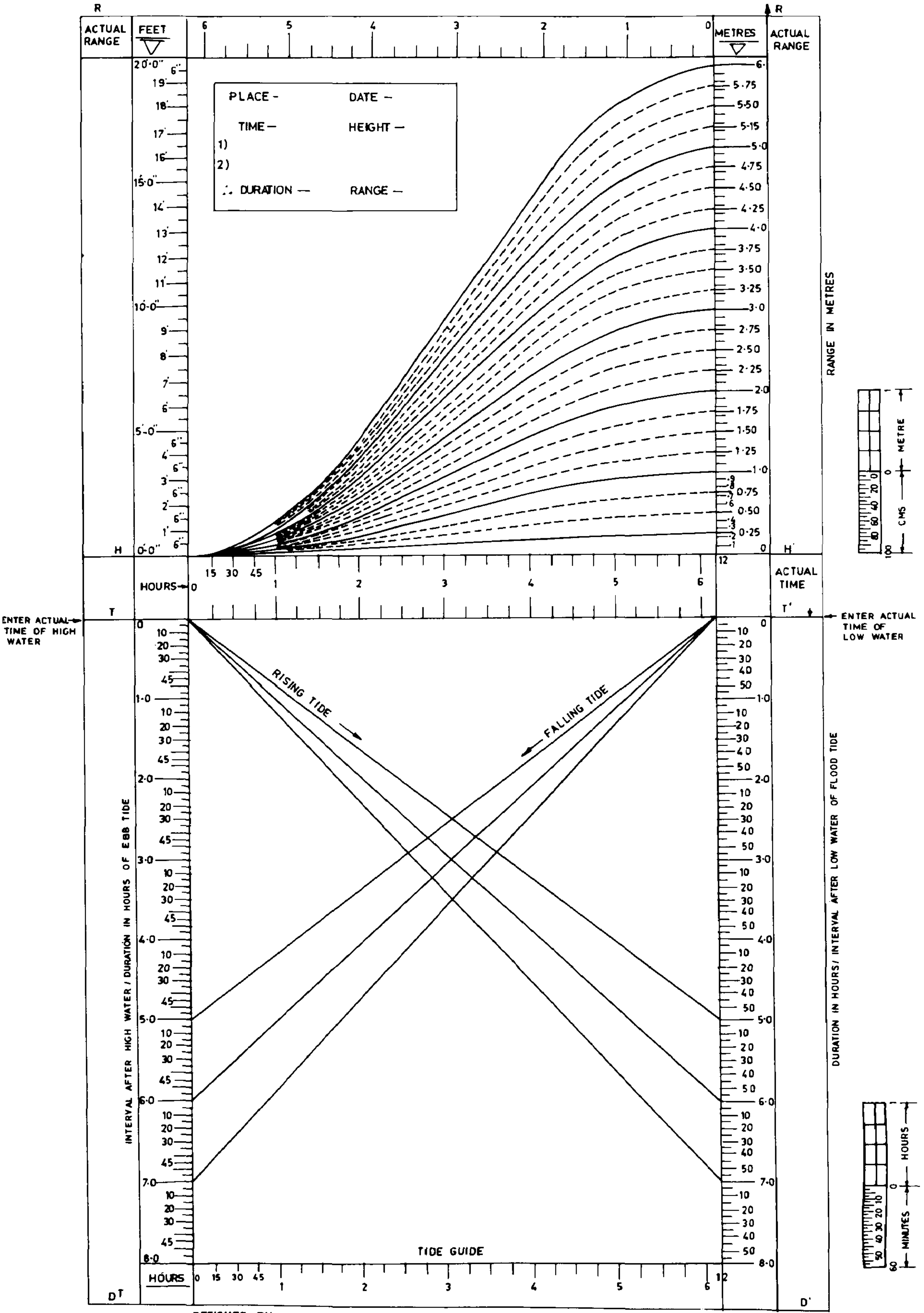
Using C, read the correction from the series of correction curves. Correction in this case is 13.1 ft approximately.

Step 7 :

Add algebraically the correction of step 6 (13.0) to the low water height to find the height at the given time. 0.85 + 13.0 = 13.85 ft or 4.22 m is the answer.

⁂

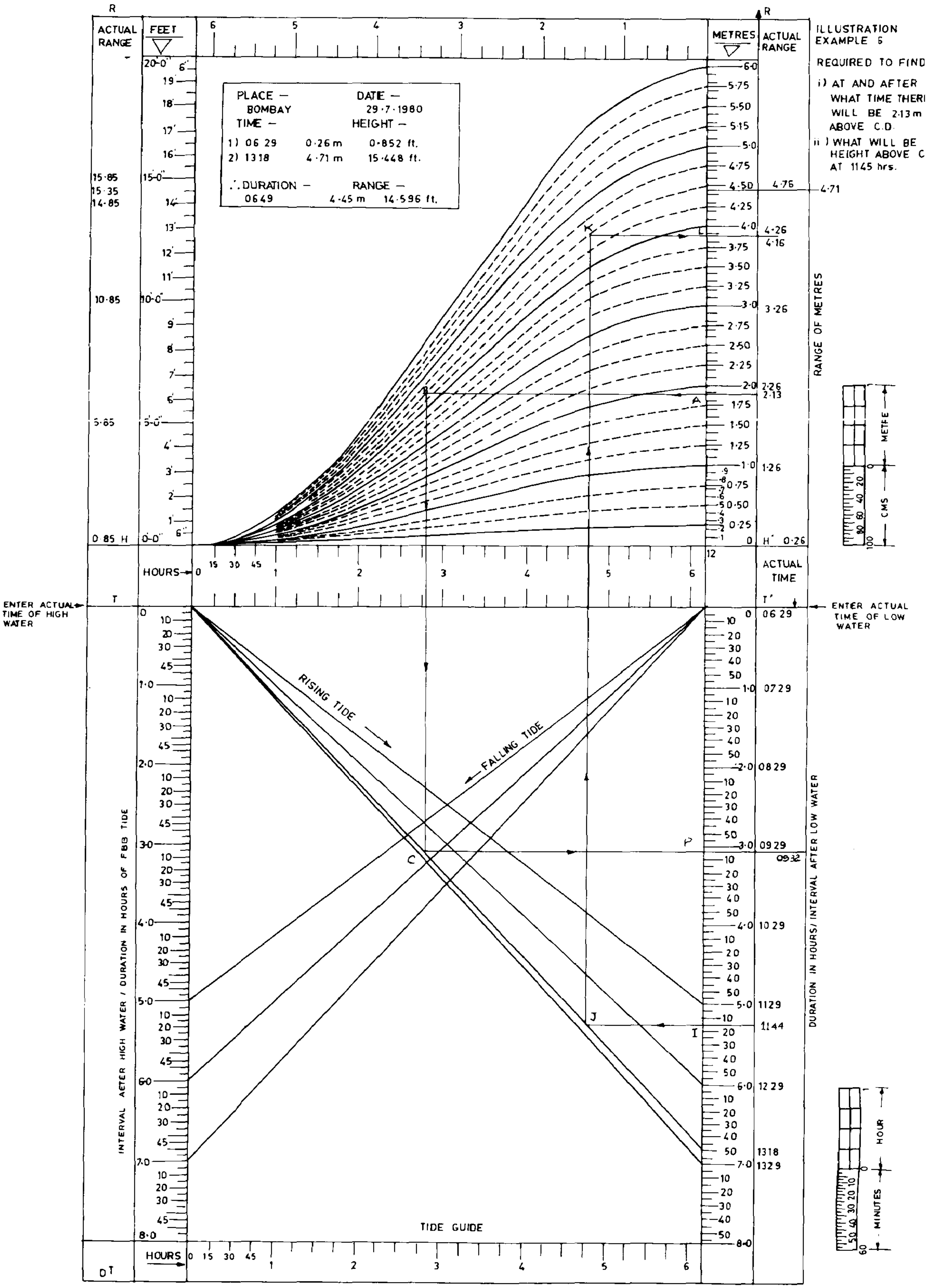
ANNEX II (i)



DESIGNED BY: Capt. M.G. JOSHI

BOMBAY PORT TRUST, BOMBAY

ANNEX II (ii)



DESIGNED BY: Capt. M. G. JOSHI
BOMBAY PORT TRUST, BOMBAY.

ANNEX II (iii)

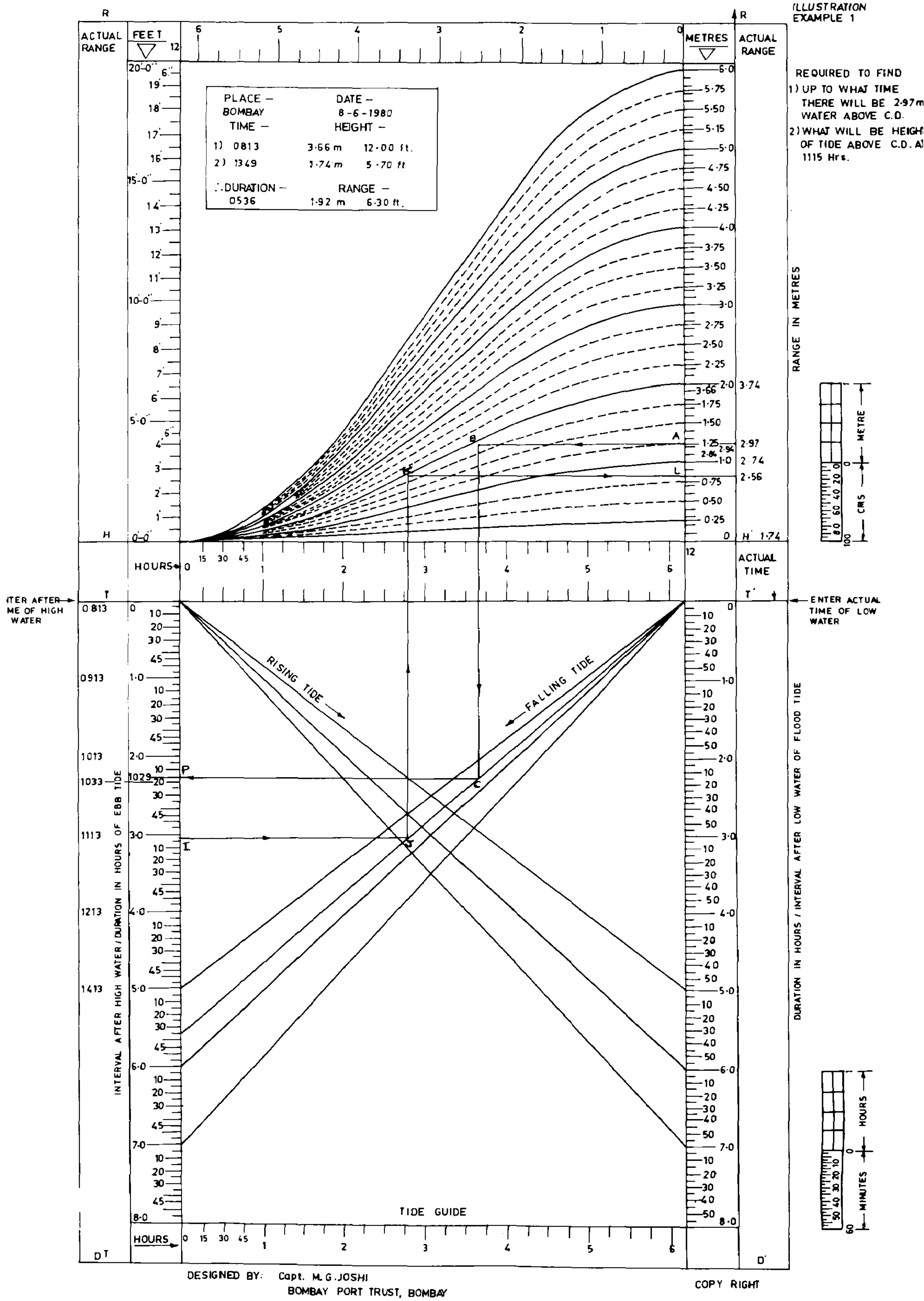


ILLUSTRATION EXAMPLE 1
REQUIRED TO FIND
1) UP TO WHAT TIME THERE WILL BE 2·97m WATER ABOVE C.D.
2) WHAT WILL BE HEIGHT OF TIDE ABOVE C.D. AT 1115 Hrs.
PLACE – BOMBAY
DATE – 8-6-1980
TIME –
HEIGHT –
1) 0813 3·66 m 12·00 ft.
2) 1349 1·74 m 5·70 ft
∴ DURATION – 0536
RANGE – 1·92 m 6·30 ft.
ACTUAL RANGE
FEET
METRES
RANGE IN METRES
3·74
2·97
2·74
2·56
H 1·74
HOURS
ACTUAL TIME
ENTER AFTER TIME OF HIGH WATER
ENTER ACTUAL TIME OF LOW WATER
0813
0913
1013
1033
1029
1113
1213
1413
RISING TIDE
FALLING TIDE
INTERVAL AFTER HIGH WATER / DURATION IN HOURS OF EBB TIDE
DURATION IN HOURS / INTERVAL AFTER LOW WATER OF FLOOD TIDE
METRE
CMS
HOURS
MINUTES
TIDE GUIDE
DESIGNED BY: Capt. M.G. JOSHI
BOMBAY PORT TRUST, BOMBAY
COPY RIGHT

ANNEX III
Comparison of results obtained by various methods

	Worked examples							
	1	2	3	4	5	6	7	8
Date Tide data	8.6.80 0813/3.66 1349/1.74	13.6.80 0555/0.17 1240/4.80	21.6.80 0016/1.83 0606/2.98	29.6.80 0609/0.39 1301/4.53	6.7.80 1206/1.85 1825/3.88	29.7.80 0629/0.26 1318/4.71	23.7.80 0208/1.41 0903/3.44	19.8.80 0517/3.21 1047/2.29
Ebb or flood	Ebb	Flood	Flood	Flood	Flood	Flood	Flood	Ebb
Range	1.92 m	4.63 m	1.15 m	4.14 m	2.03 m	4.45 m	2.03 m	0.92 m
Duration	0536	0645	0550	0652	0619	0649	0655	0530
Neap or Spring	N	S	N	S	N	S	N	N
Problem A : To find at/after/up to what time there will be a certain height of tide above Chart Datum								
Required height	2.97 m	3.04 m	2.13 m	1.98 m	2.59 m	2.13 m	2.59 m	2.89 m
Time found by method :								
(i) R.O.T.	1029	0950	0216	0903	1441	0931	0558	0727
(ii) A.T.T.	1033	0954	0216	0906	1445	0935	0556	0729
(iii) Correct.	1030	0949	0216	0903	1442	0933	0557	0729
(iv)								
(v) Ready Reck. (American Nav.)	1027	0951	0219	0905	1445	0933	0556	0729
(vi) Graphical (American Nav.)	1034	0945	0215	0907	1444	0932	0553	0731
(vii) TIDE GUIDE	1029	0953	0216	0907	1447	0931	0555	0732
(viii) Bombay Port Trust's Prediction	1013	0952	0233	0904	1453	0930	0550	0713
Actual time	1029	0943	0143	0845	1432	0934	0604	0717
Problem B : What the height will be at a given time								
Given time	1115	0900	0430	1115	1630	1145	0800	0630
Height found by method								
(i) R.O.T.	2.58	2.19	2.77	3.86	3.44	4.13	3.32	3.09
(ii) A.T.T.	2.58	2.11	2.77	3.80	3.45	4.17	3.32	3.09
(iii) Corr.	2.55	2.16	2.78	3.90	3.45	4.16	3.32	3.10
(iv) —	2.575	2.172	2.775	3.89	3.452	4.16	3.32	3.10
(v) R.R.	2.59	2.17	2.76	3.90	3.48	4.16	3.34	3.08
(vi) Graph	2.59	2.17	2.78	4.0	3.5	4.2	3.3	3.1
(vii) TIDE GUIDE	2.58	2.18	2.79	3.85	3.48	4.16	3.31	3.10
(viii) B.P.T. Prediction	2.42	2.11	2.70	3.88	3.39	4.17	3.35	3.06
Actual height	2.55	2.28	2.83	4.18	3.59	4.13	3.32	3.05

Note : The difference between Bombay Port Trust's Prediction, actual time or height and the results obtained by various methods may be due to south west monsoon conditions prevailing in these months.