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TOPIC 3

TIDE

UNIVERSITI TEKNOLOGI PETRONAS
energising futures

COURSE LEARNING OUTCOMES

Upon completion of this course, students should be able to:

1. Evaluate the properties of offshore and near shore waves and establish design wave specification.
2. Assess currents and tidal processes.
3. Formulate sediment budget and perform shoreline evolution analysis.

LEARNING OUTCOMES

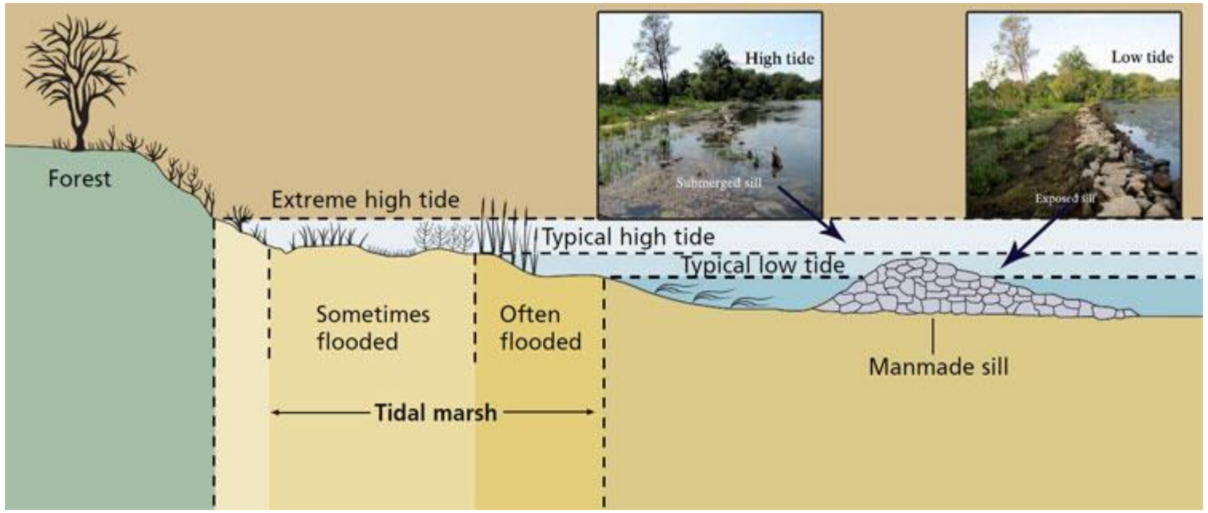
Upon completion of this topic, participants should be able:

- To assess tidal effects on the ocean water.
- To understand different tidal levels.

WHAT ARE TIDES?

- Very long-period waves moving through the oceans in response to the forces exerted by the moon and sun.
- Originated in the oceans and progress towards coastlines.
- The regular rise and fall of the sea levels causing change in current speed and direction.

Name	Typical Periods	Wave lengths	Forcing Mechanism
Ripples	< 0.2 s	10^{-2} m	wind on sea surface
Sea	0.2 - 9 s	10s of m	"
Swell	9 - 30 s	100s of m	"
Internal	min to several hrs	1 - 300 m	current shear on stratification
Planetary and Topographic	hours to days	100-1000s km	bathymetry/atmospheric pressure
Tsunamis	15 min to 1 hr	few 100s km	seismic, landslide, meteorite impact
Tides	**several hrs**	**100s -1000s km**	**gravitational (moon and sun mainly)**

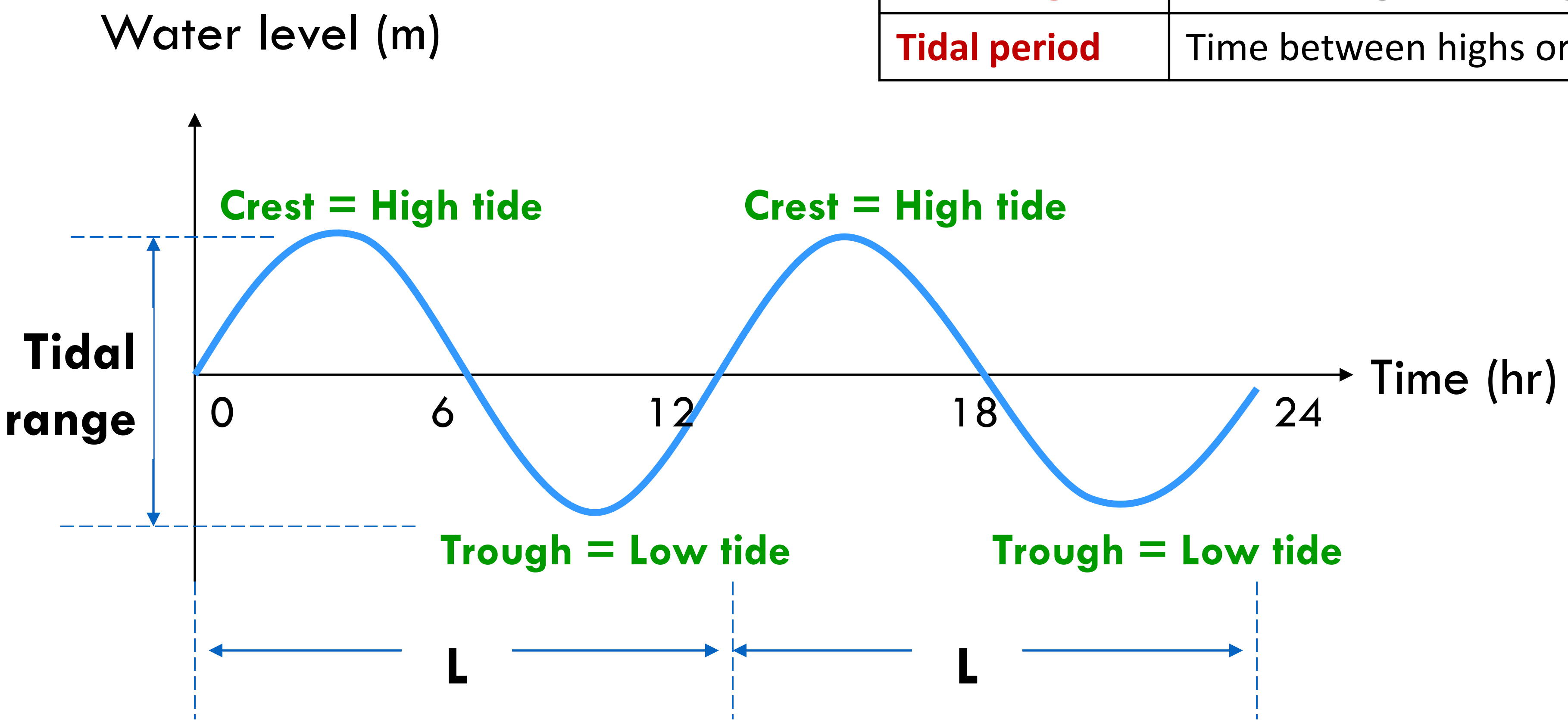


- High water – Maximum height reached by a rising tide
- Low water – Maximum height reached by a falling tide

TIDAL CYCLE

UTP

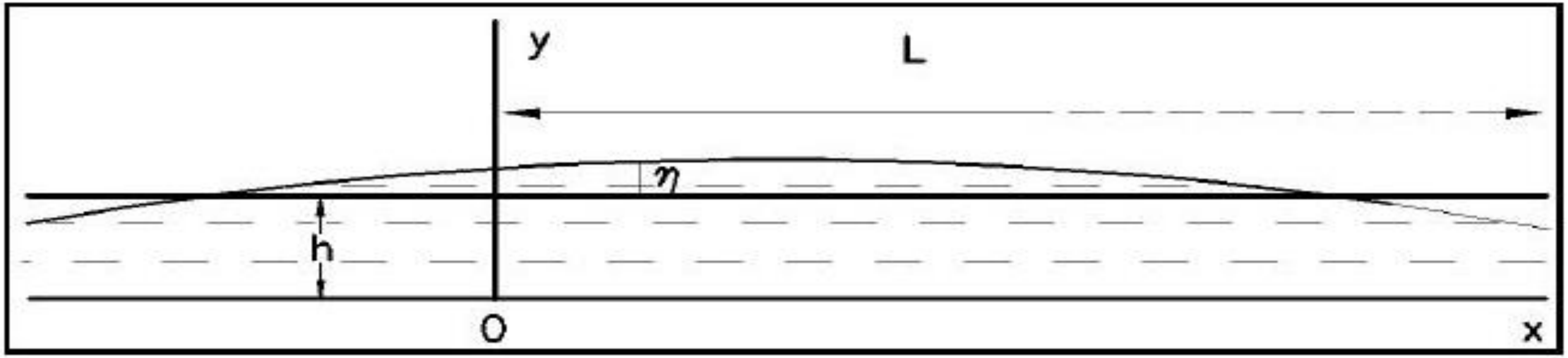
Term	Definition
Tidal range	Vertical height from high to low
Tidal period	Time between highs or lows



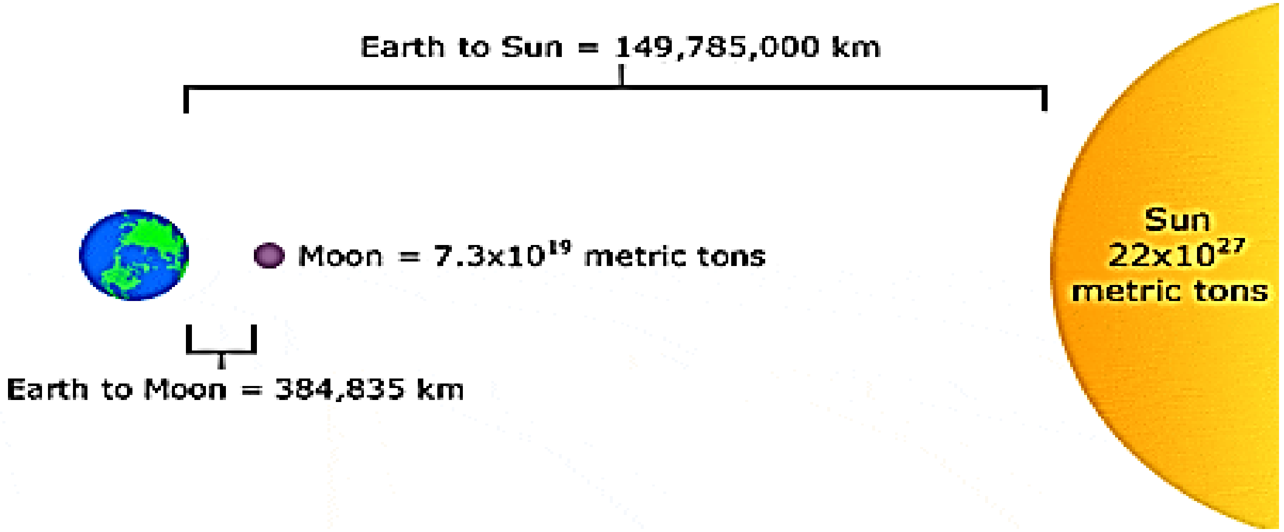
Is Tides a Shallow Water Wave?

Because of its long period, the tide propagates as a shallow water wave even over the deepest parts of the ocean.

$$L >> d; \quad d/L < 0.05 \quad \Rightarrow \text{ Shallow water}$$



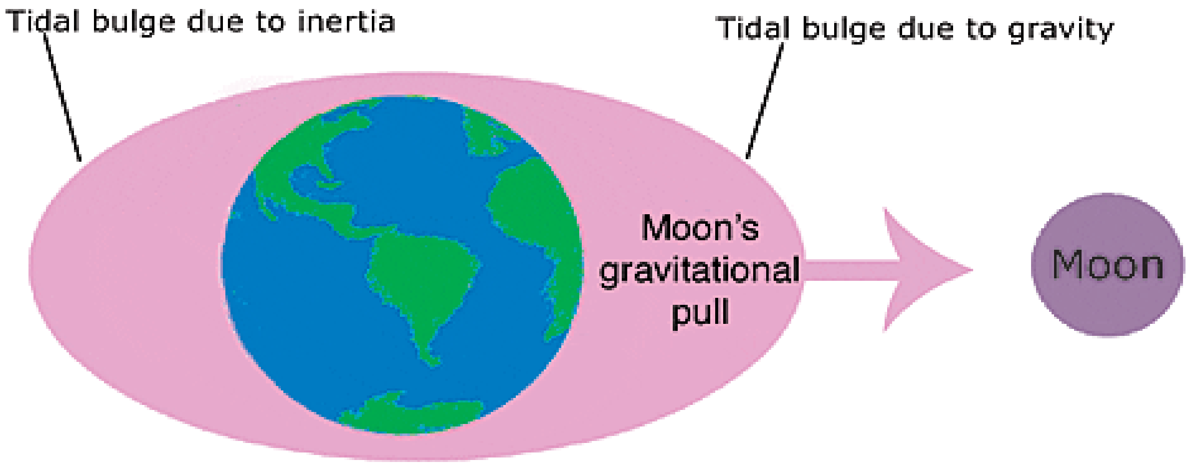
FORMATION OF TIDES

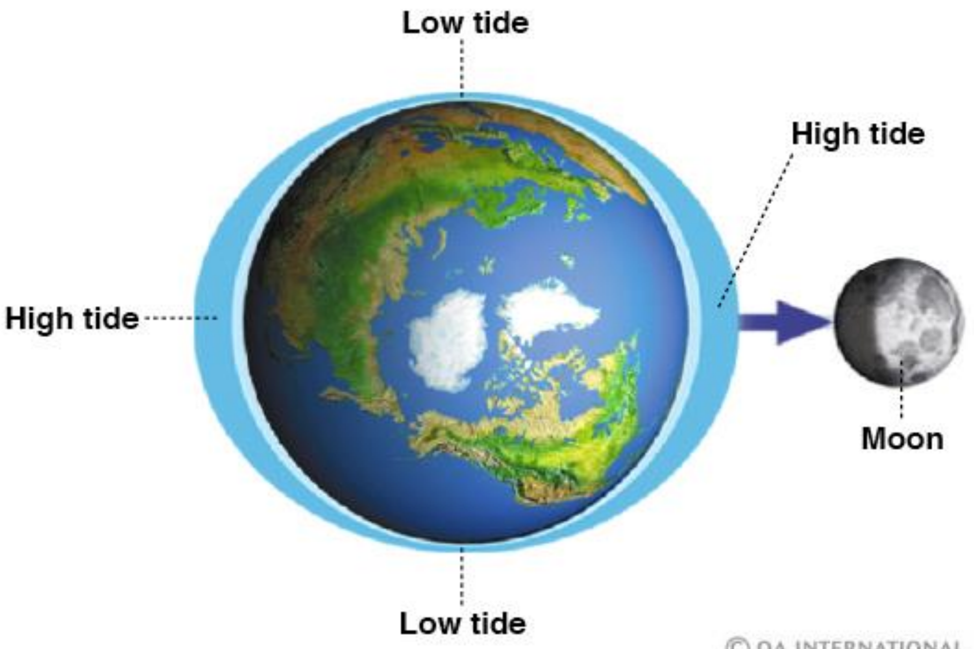


- Tides result from the gravitational attraction of the sun and moon on the oceans of the earth.

- Newton's law of universal gravitation: The greater the mass of the objects and the closer they are to each other, the greater the gravitational attraction between them.
- The moon has the biggest influence (about twice the sun's gravitational force on the oceans) because it is close. The sun tugs on the oceans too, but since it's so far away, it has less influence than the moon.

GRAVITY & INERTIA FORCES





- Gravity: The major force creating tides
- Inertia (counterbalance gravity): Caused by centrifugal force
- Gravity and inertia created the two tidal bulges on the earth.

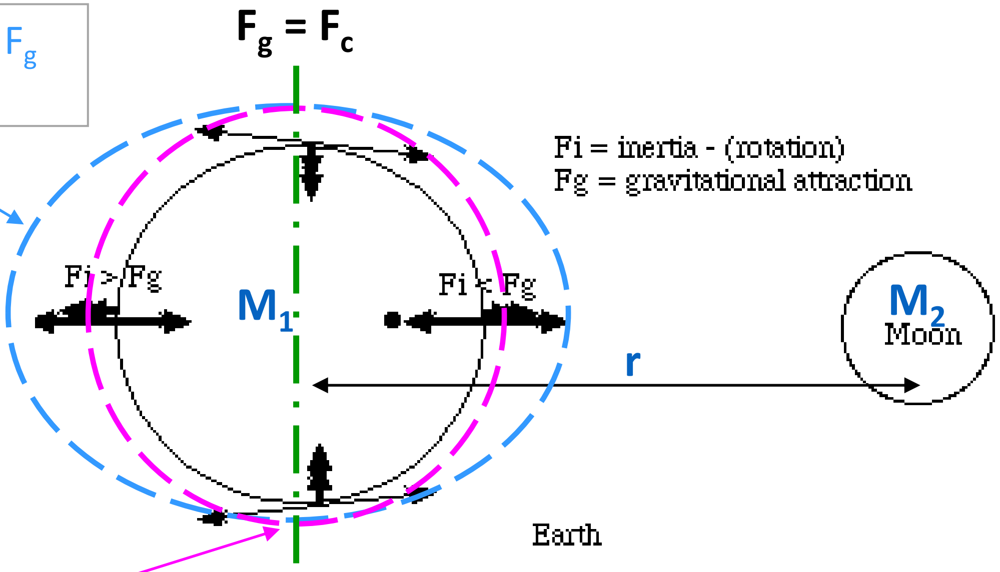
TIDE GENERATION

2 forces operating on the water envelope:

Gravitational force (F_g) & Centrifugal force (F_i)

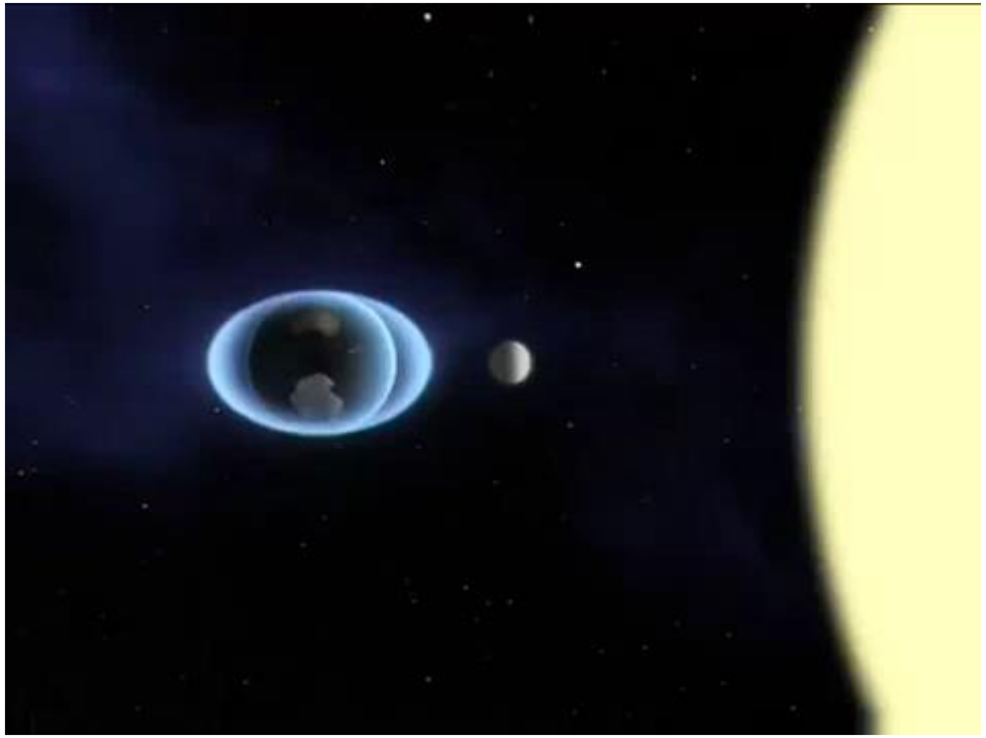
Water surface due to F_g and F_i (**Lunar tide**)

F_i pull the water away from the Earth's surface



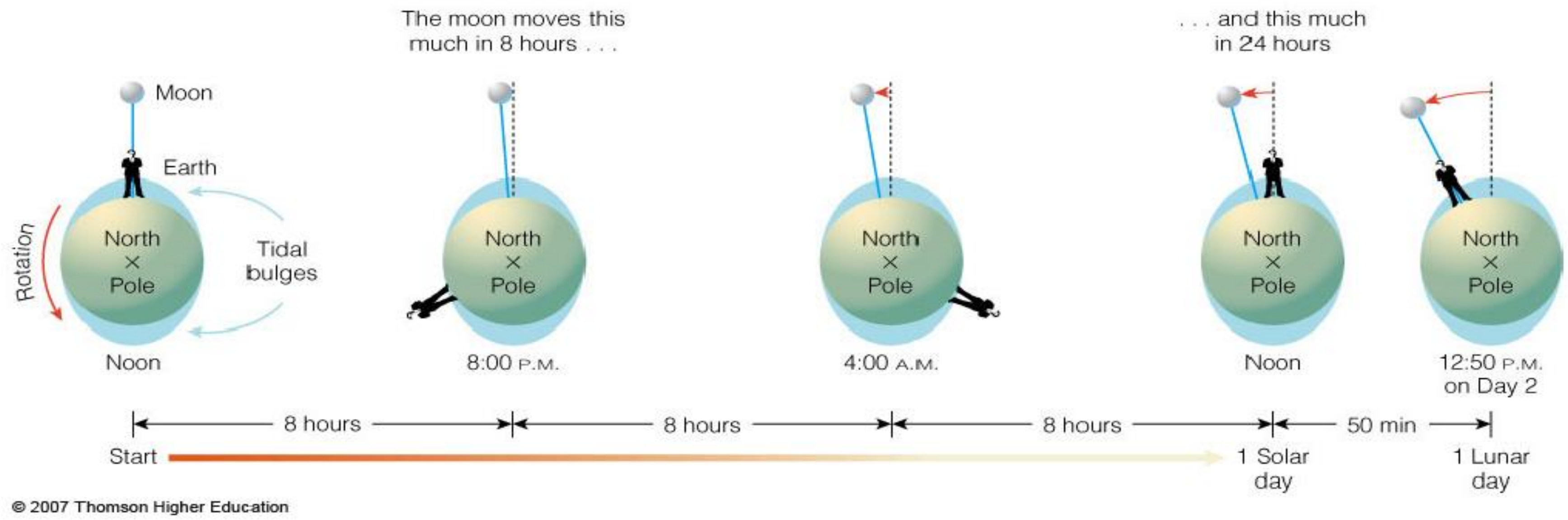
Water surface without F_g and F_i (**Solar tide**)

$$F_g = M_1M_2/r^2$$



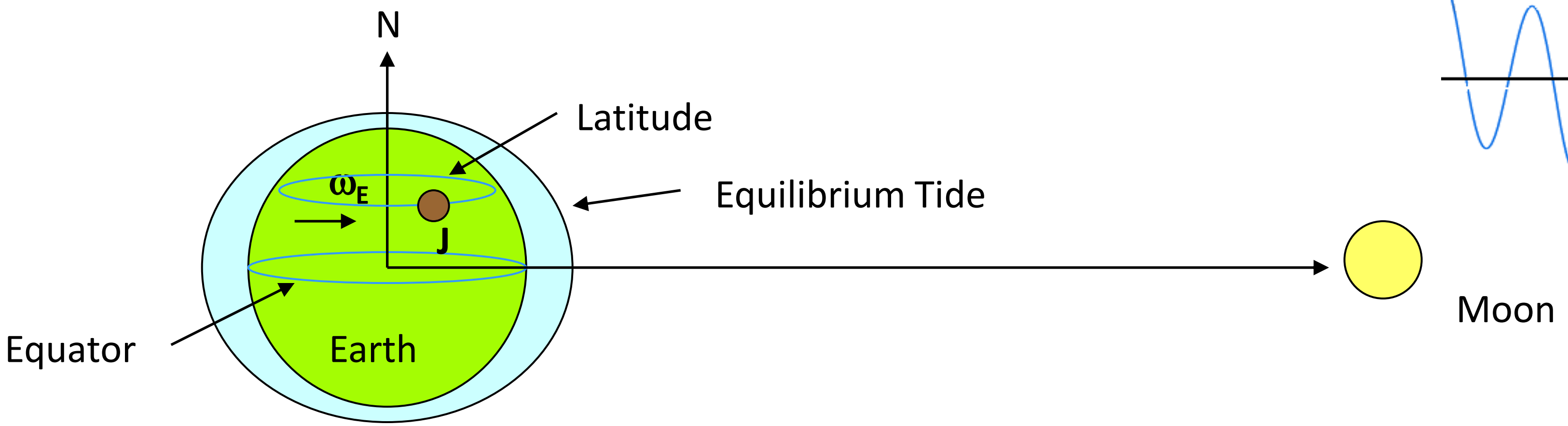
Most area, experience two high tides and two low tides every lunar day (Note: Solar day – 24 hours; Lunar day – 24 hours 50 minutes)

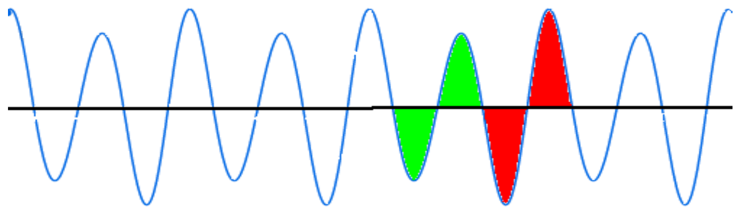
Solar Day vs Lunar Day



	Christian Calendar	Lunar Calendar
Based on	Rotation of the Sun-Earth system	Rotation of the Moon-Earth system
Day	Solar day	Lunar day
No. of hours in a day	24 hr	24 hr 50 min
No. of days in a month	30.42 days	29.53 days
No of days in a year	30.42 x 12 = 365 days	29.53 x 12 = 354.36 days

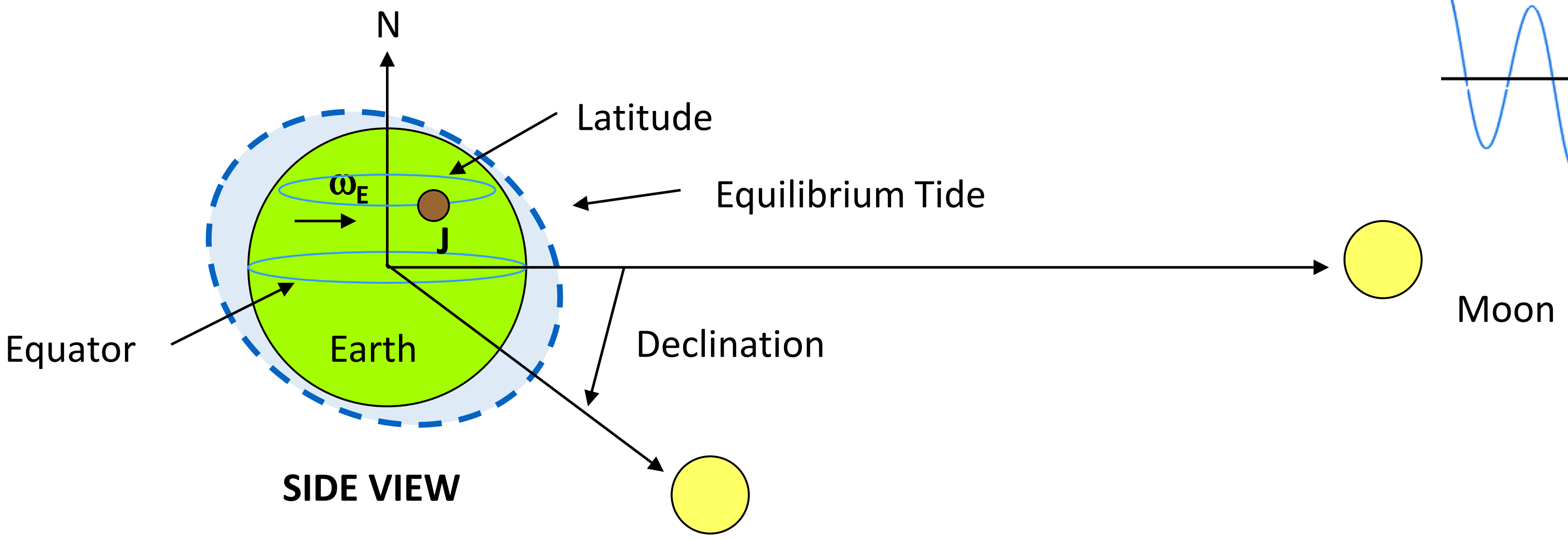
Daily Inequality

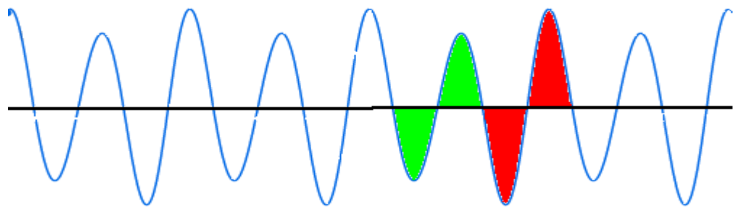




SIDE VIEW

When the moon is in the plane of the equator, an observer traveling along a constant latitude would experience 2 tides of **equal height** height per day.



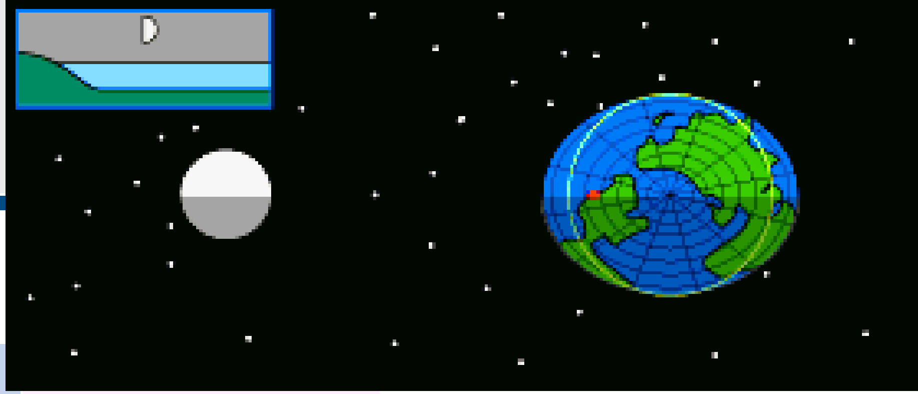


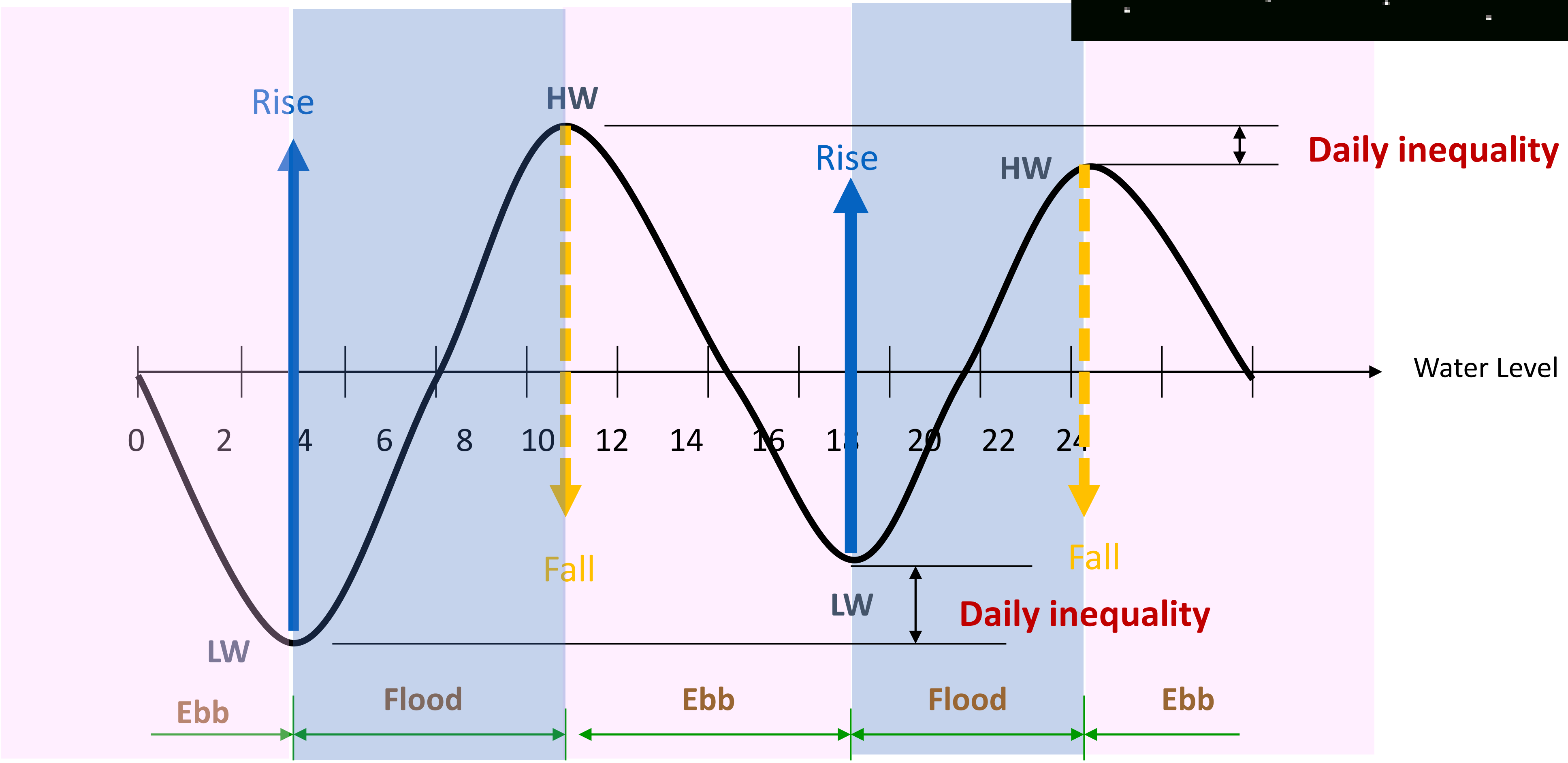
When the moon is in the plane of the equator, an observer traveling along a constant latitude would experience 2 tides of **equal height** height per day.

When the moon has a North/South declination with respect to the equator, he/she would experience 2 tides day of **unequal height**.

Daily inequality is the difference between two successive low or high tides.

DAILY WATER LEVELS

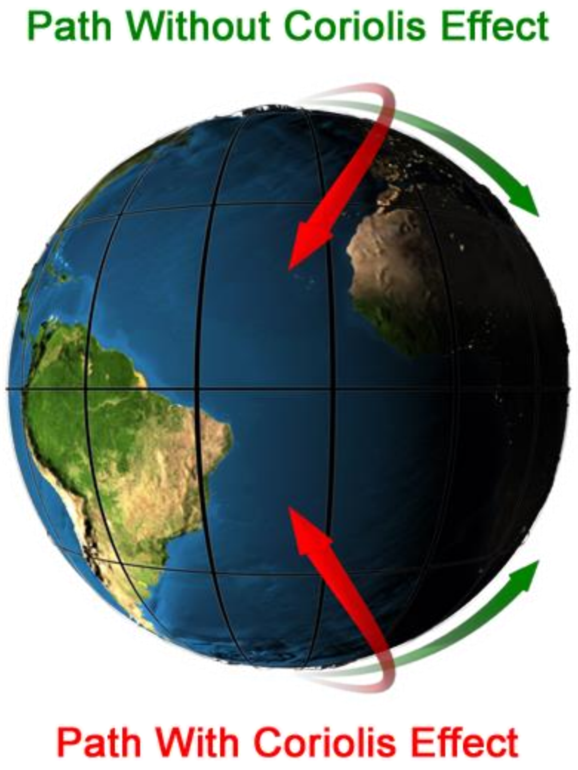




TIDE PROPAGATION

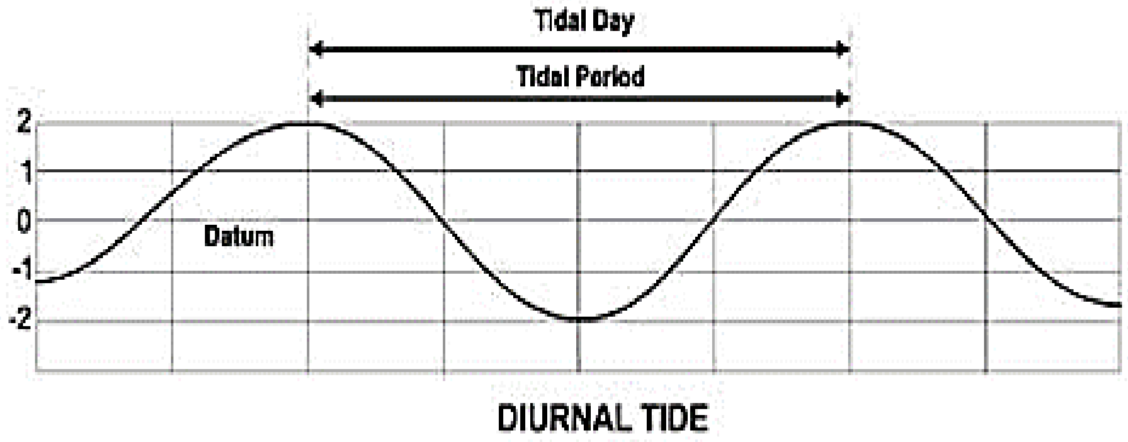
Tide propagation and the amplitude are influenced by:

- nearshore hydrography
- bottom friction
- the rotation of the earth (Coriolis acceleration)
- resonance determined by the shapes and depths of the ocean basins.



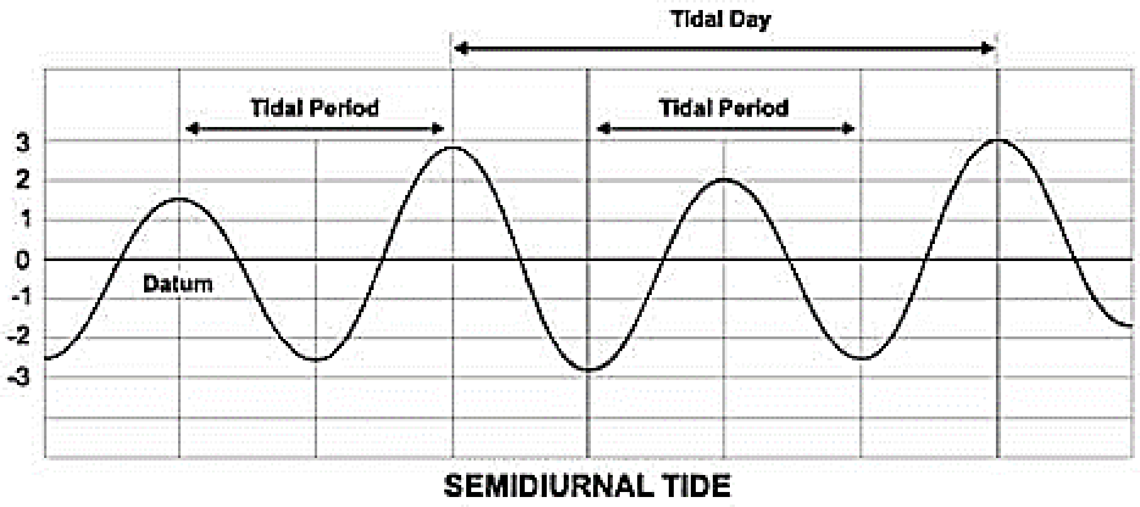
DIURNAL & SEMIDIURNAL TIDES

Diurnal Tides (Daily Tides)



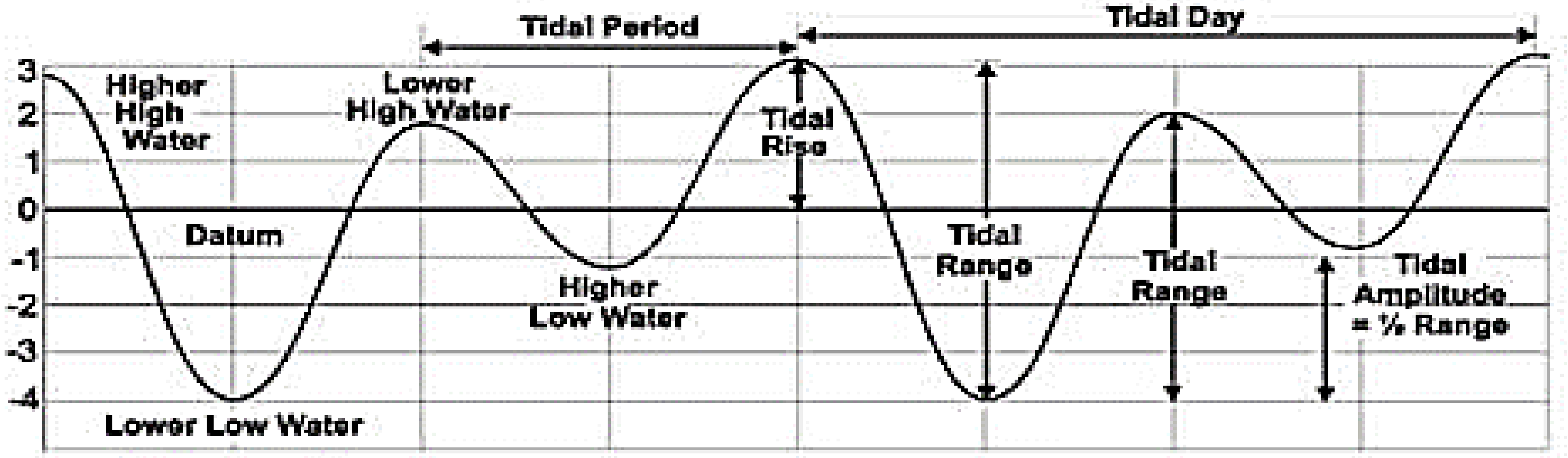
- One high and one low tide per day
- These have periods close to 24 hours

Semidiurnal Tides (Half Daily Tides)



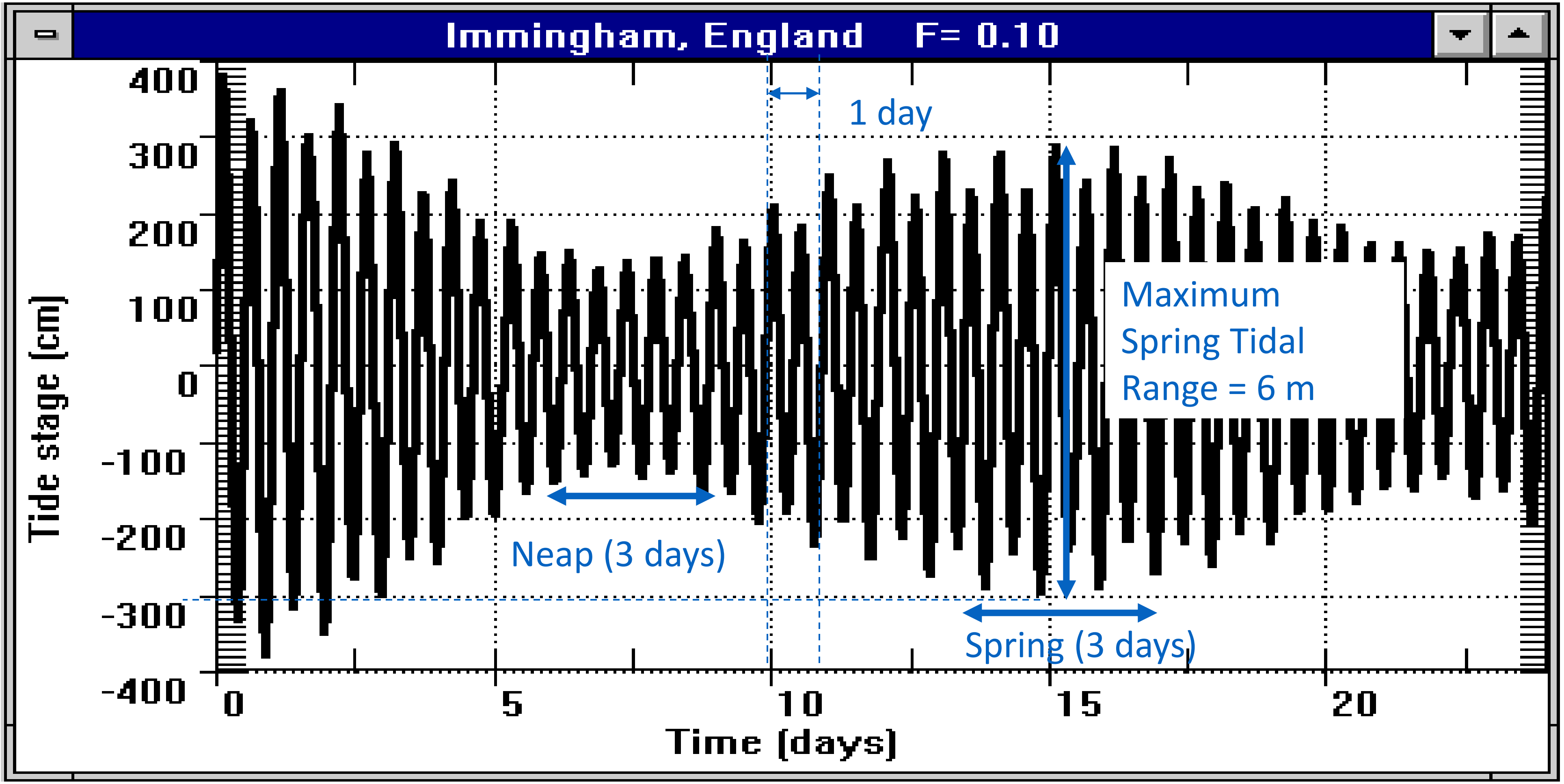
- Two highs and two lows daily tides are about the same height
- These have periods close to 12 hours

Mixed Tides



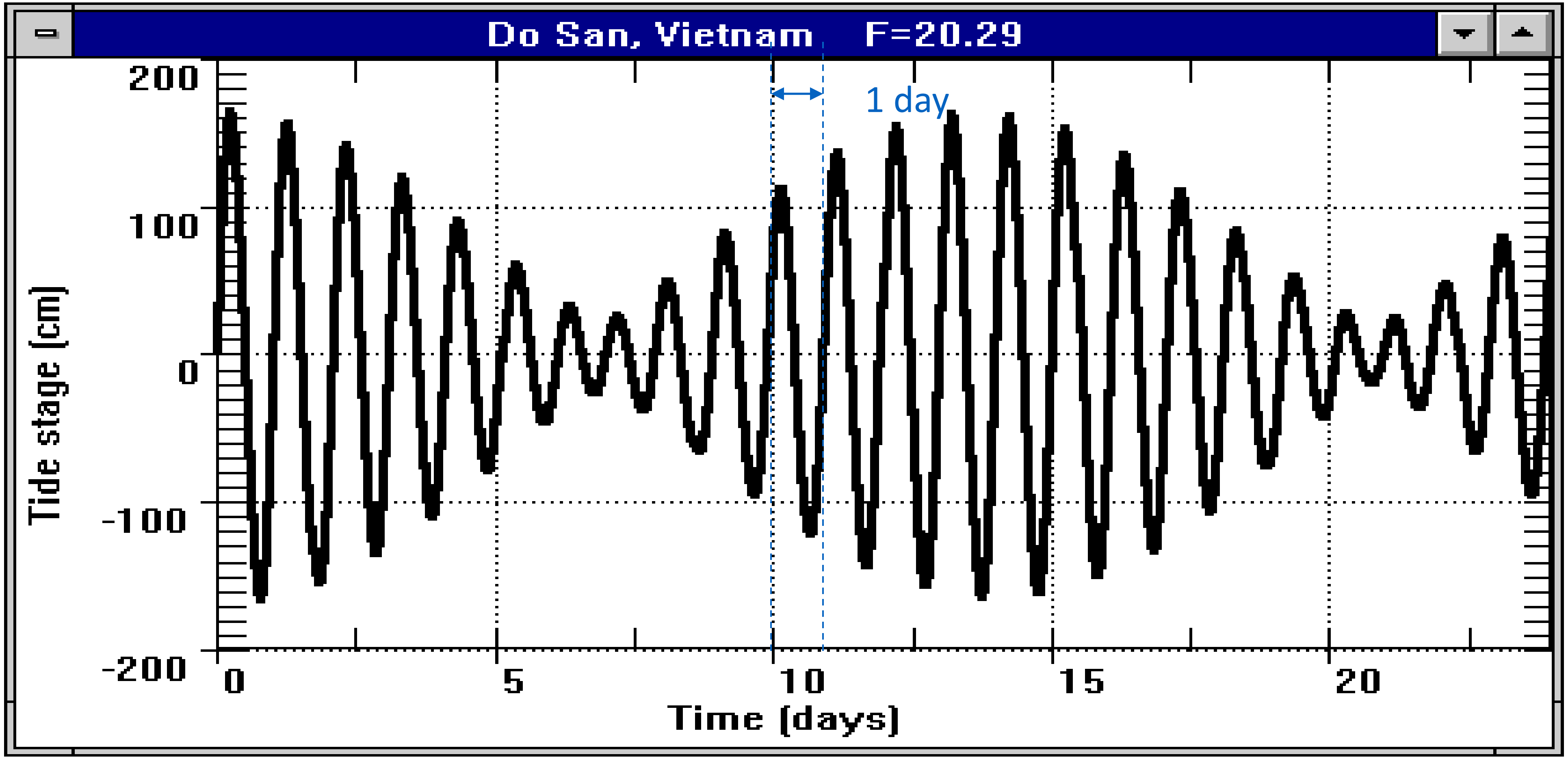
- Variable height between lows and highs (a large inequality in the vertical range)
- Mixture of semidiurnal and diurnal

Semidiurnal Tides



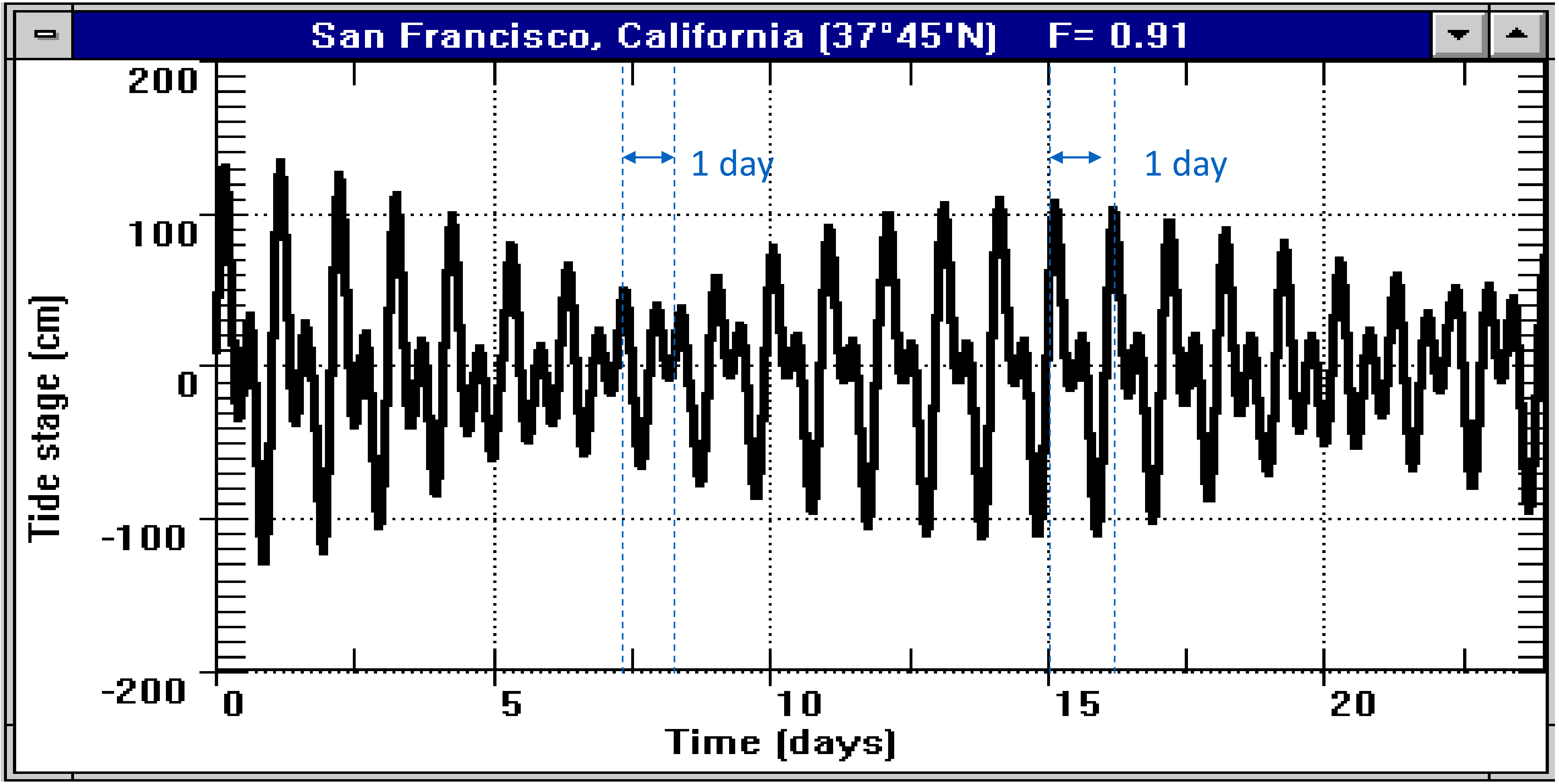
Two high and low waters each day

Diurnal Tides



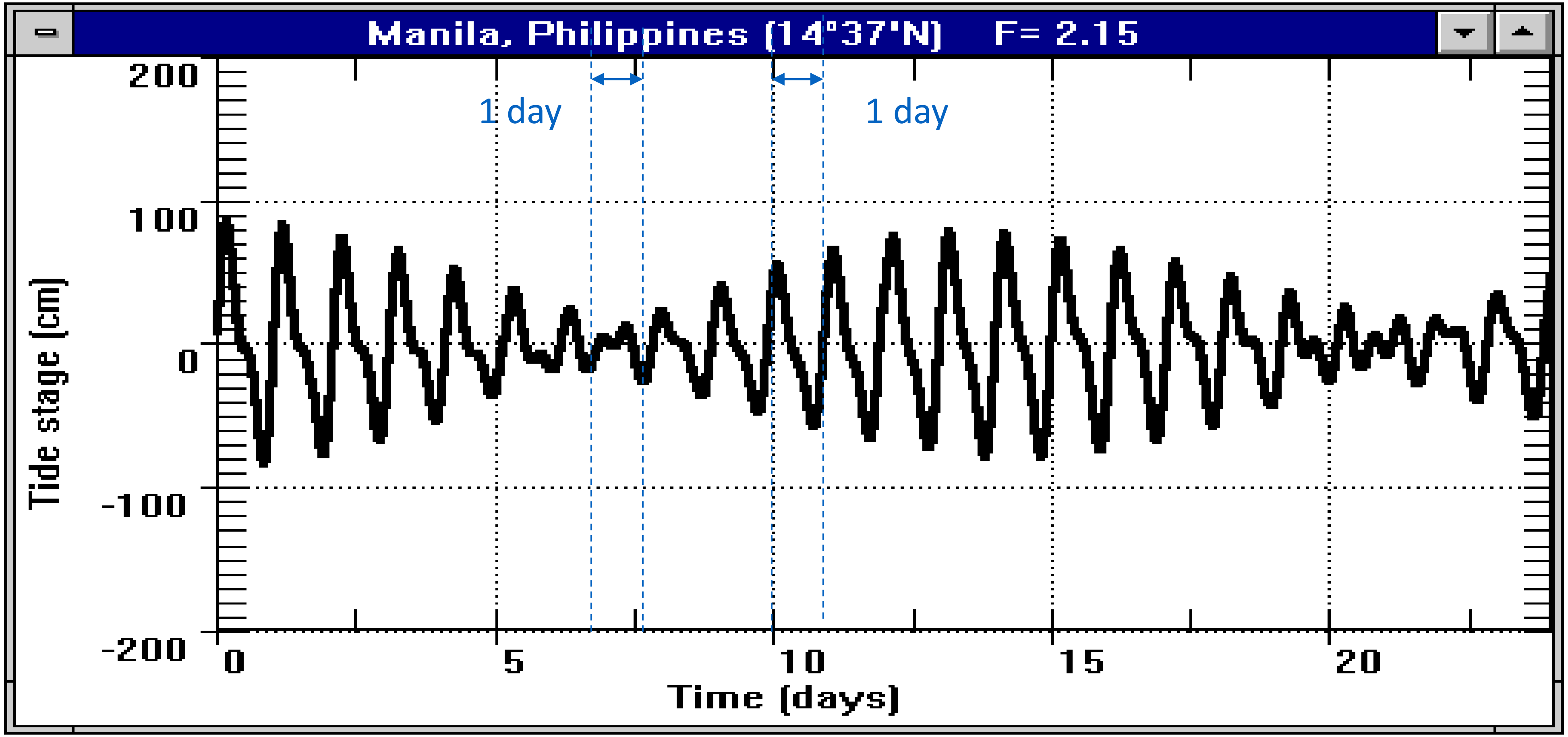
One high and low waters each day

Mixed Predominantly Semidiurnal Tides



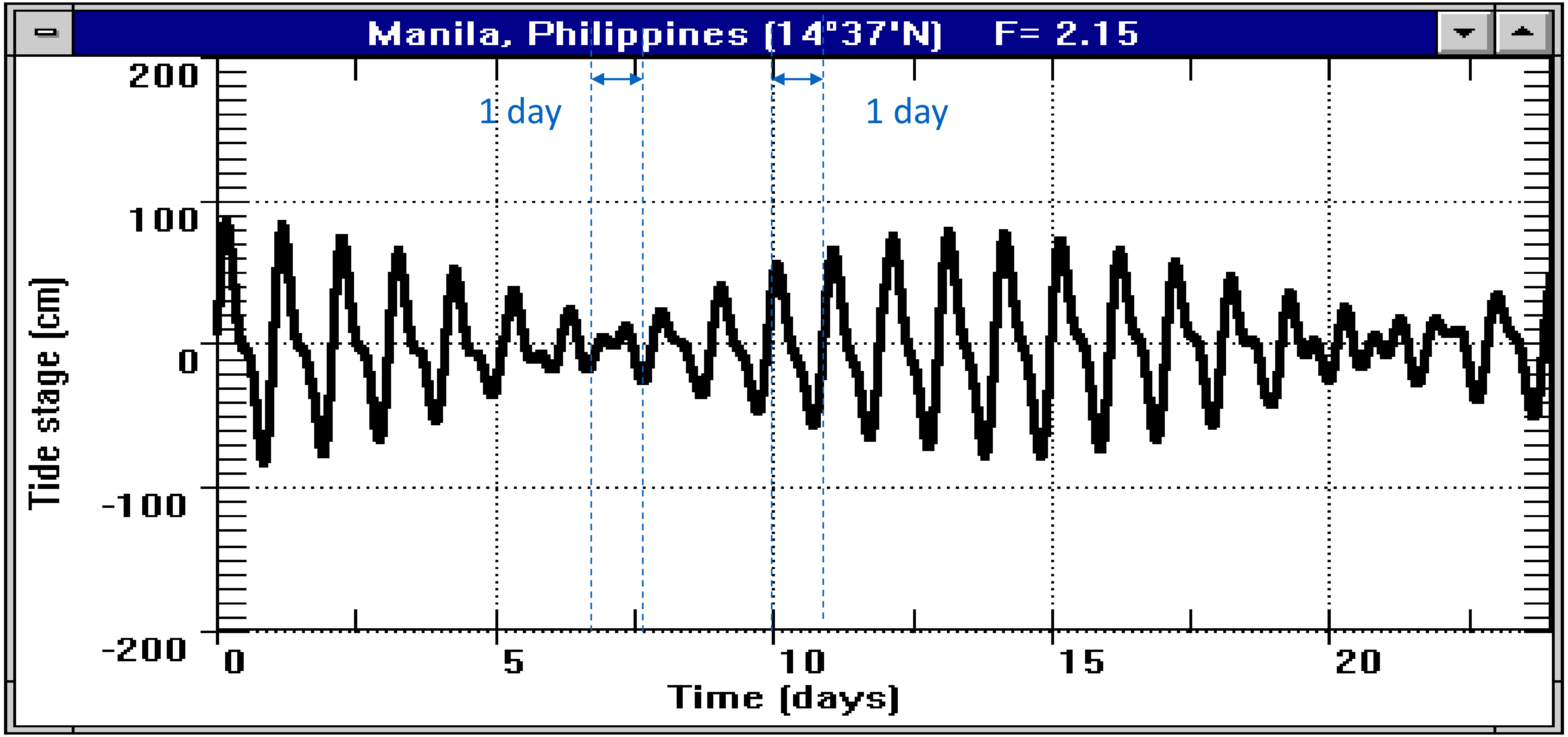
Two high and low waters each day during most of the time, only one high and low water during neap tides

Mixed Predominantly Diurnal Tides



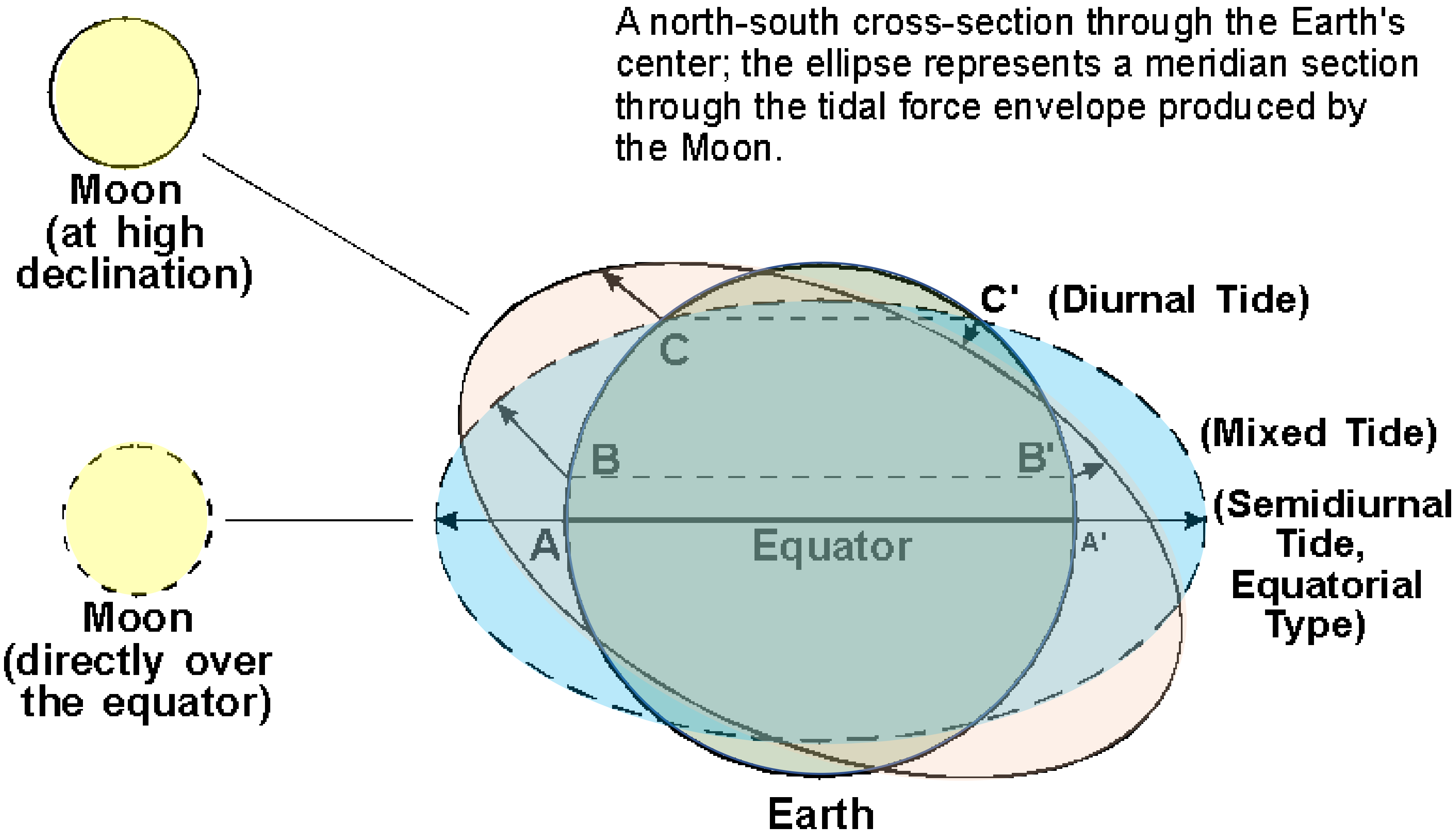
One dominant high and low water each day, two high and low waters during neap tide

Mixed Predominantly Diurnal Tides

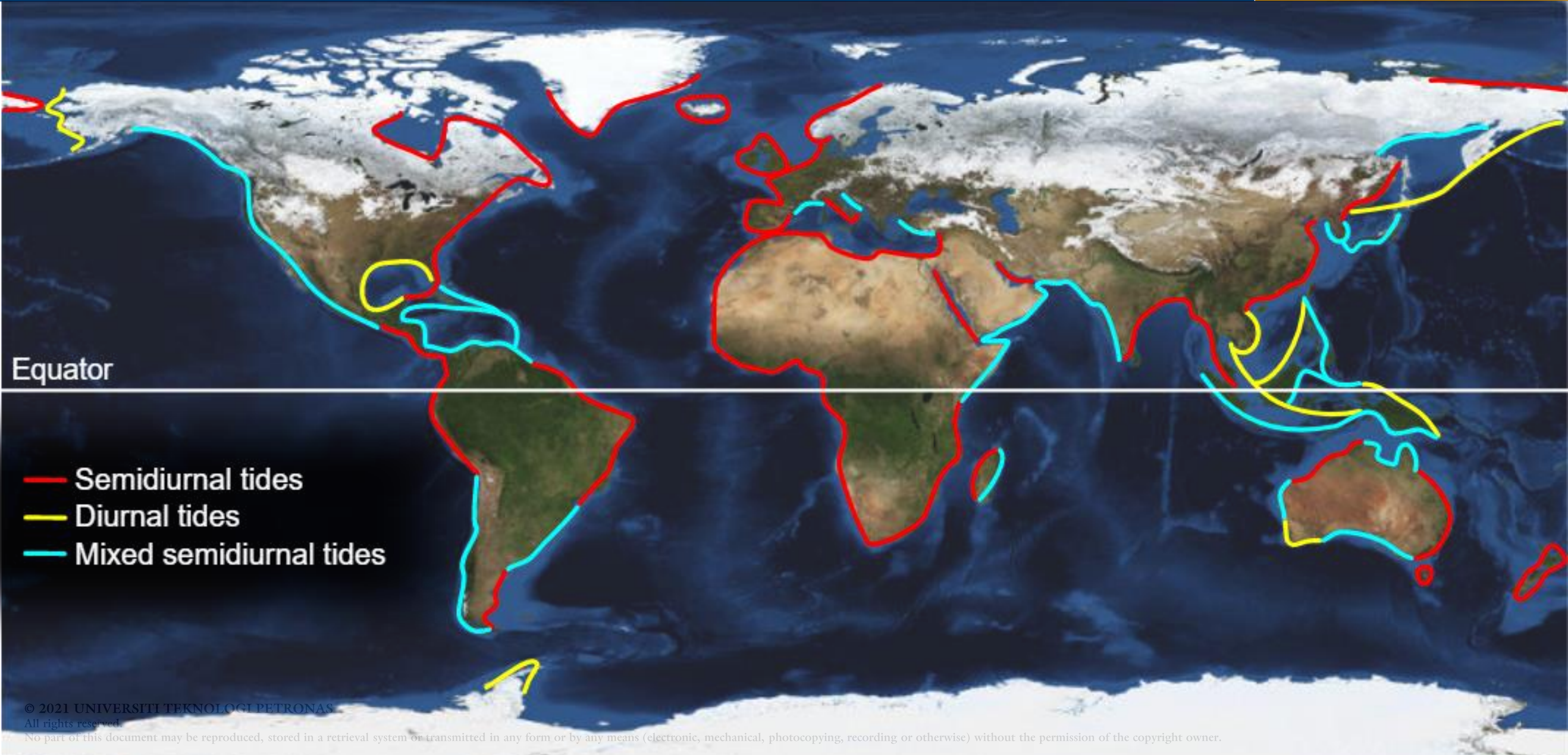


One dominant high and low water each day, two high and low waters during neap tide

OCCURRENCE OF TIDES

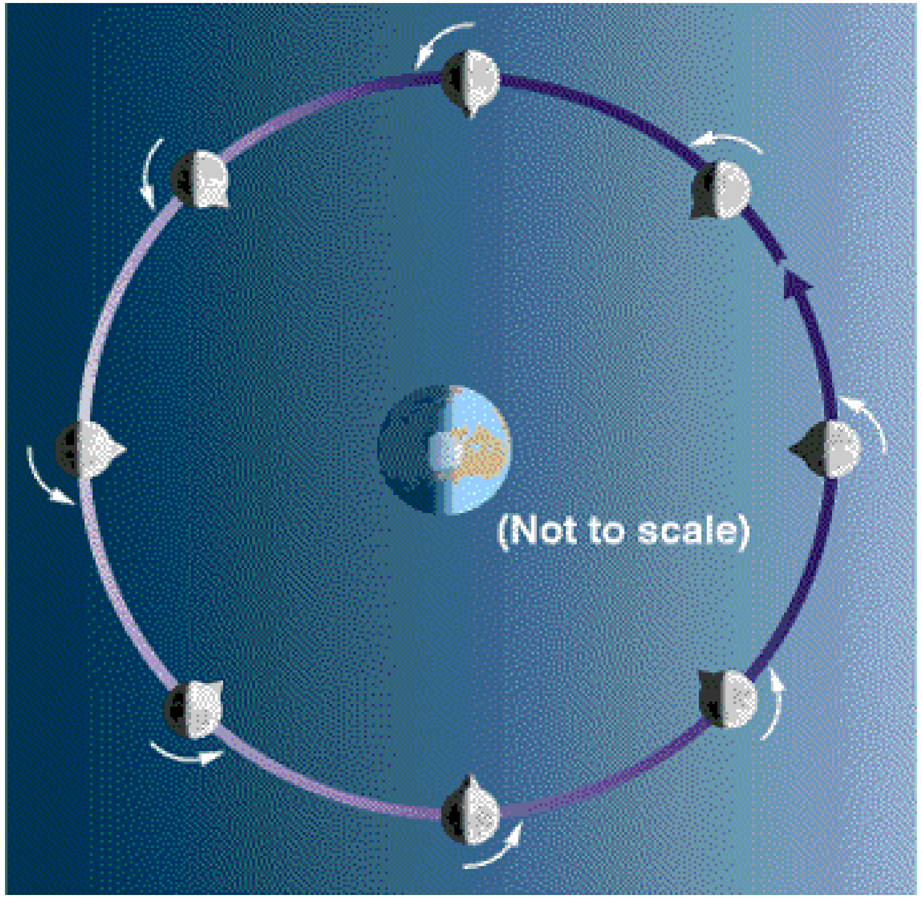


Occurrence of Tides



Occurrence of Tides

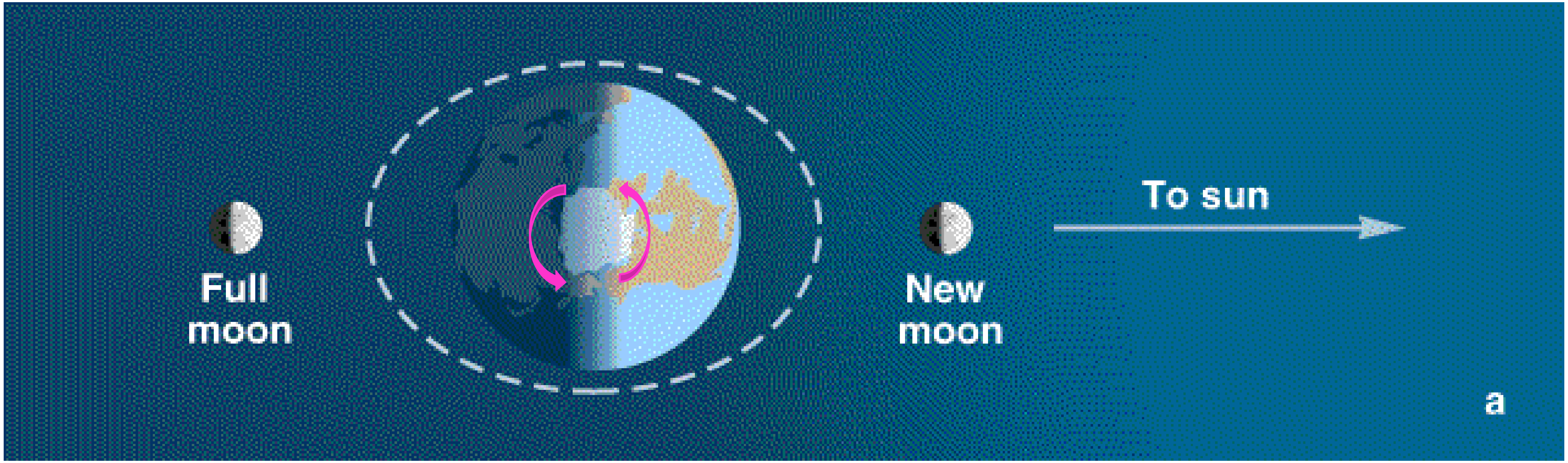
Moon's Synchronous Orbit



Seen from above the earth's North Pole, the moon's orbit carries it counterclockwise around the earth once every 29.5 days.

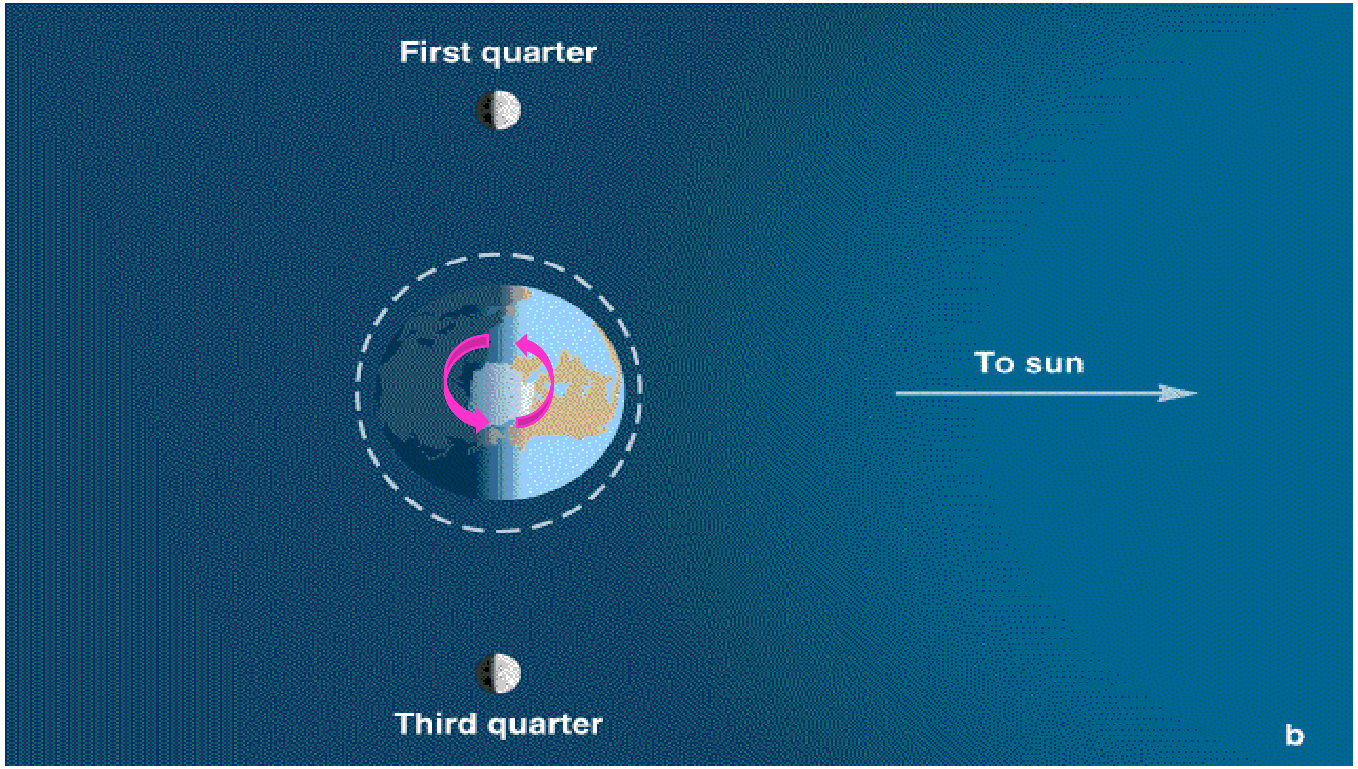
As it follows its orbit, the moon itself also rotates counterclockwise and keeps the same side facing the earth.

SPRING TIDES



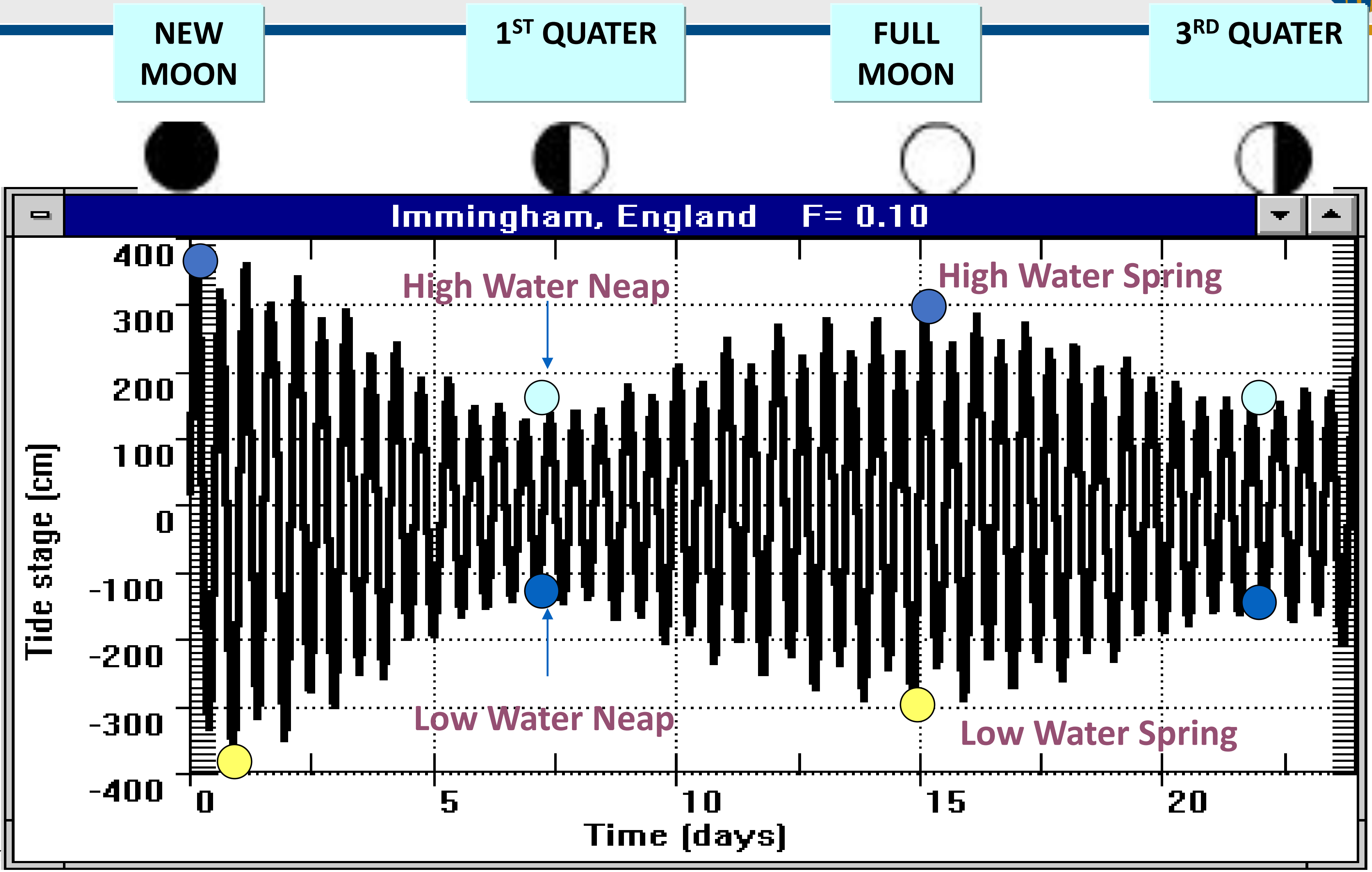
When the sun, moon and earth are all aligned (occurred during the new moon and the full moon), the gravitational pull of the moon and sun are combined, resulting the lunar tidal bulges added on top of the solar tidal bulges. At these times, the high tides are very high and the low tides are very low. This is known as a spring tides which occur twice a month.

NEAP TIDES



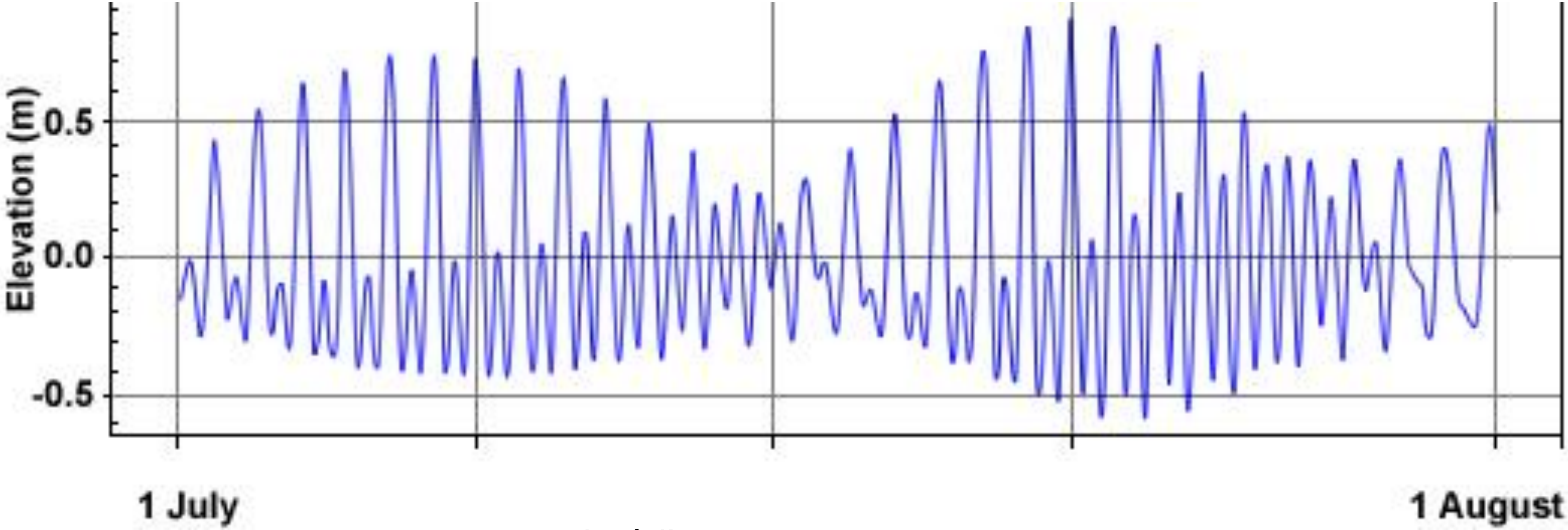
When the moon is in the first and third quarters, the sun and moon work at right angles, causing the bulges to cancel each other. This result in a smaller difference between high and low tides and is known as a neap tides. Neap tides are especially weak tides.

Animation: Spring & Neap Tides



NEW MOON
1ST QUATER
FULL MOON
3RD QUATER
Immingham, England F= 0.10
High Water Neap
High Water Spring
Low Water Neap
Low Water Spring
Tide stage [cm]
Time [days]
400
300
200
100
0
-100
-200
-300
-400
0
5
10
15
20

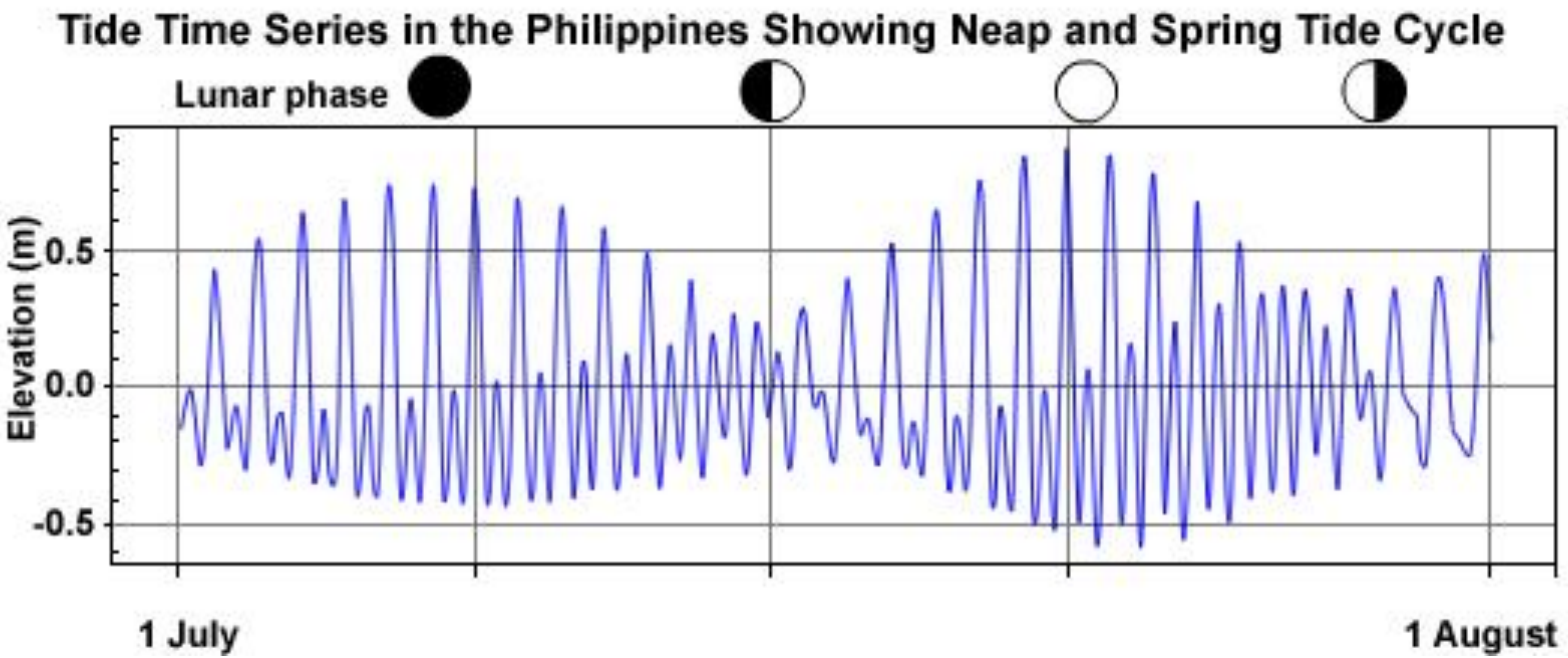
PROBLEM



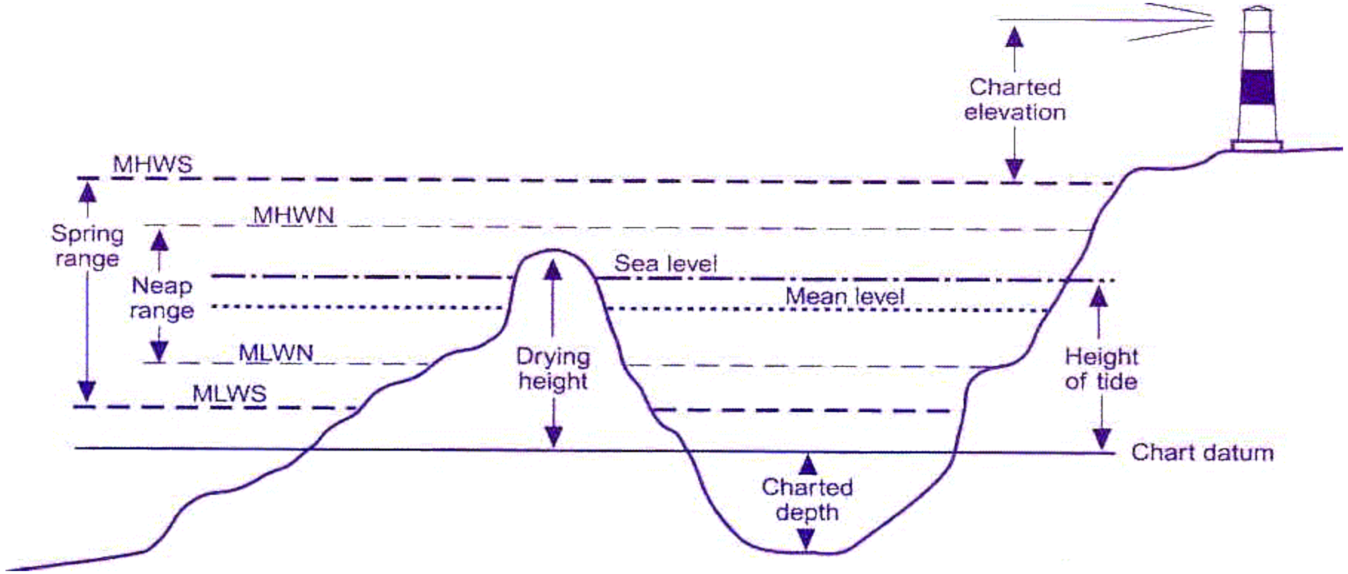
Determine the following:

a. The type of tides
b. The occurrences of new moon, 1st quarter moon and full moon
c. The possible dates for spring and neap tides
d. Maximum tidal range

SOLUTION (B)

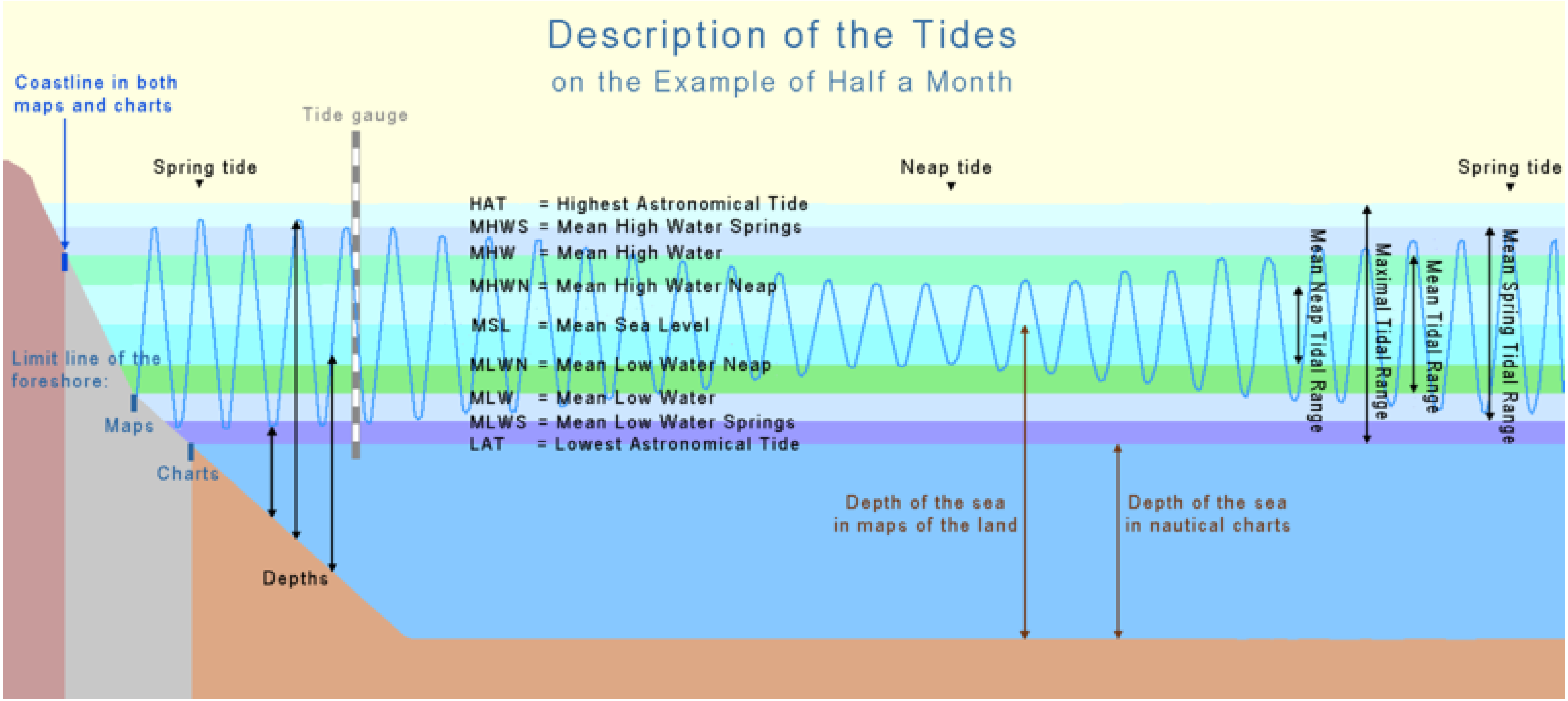

Tide Time Series in the Philippines Showing Neap and Spring Tide Cycle
Lunar phase
Elevation (m)
0.5
0.0
-0.5
1 July
1 August

Tidal Datum



- A tidal datum is a standard elevation defined by a certain phase of the tide.
- Tidal datum are used as references to measure local water levels.
- Coastal water elevation are referred to a variety of tidal datum e.g. MSL (mean sea level), ACD (Admiralty Chart Datum), etc.

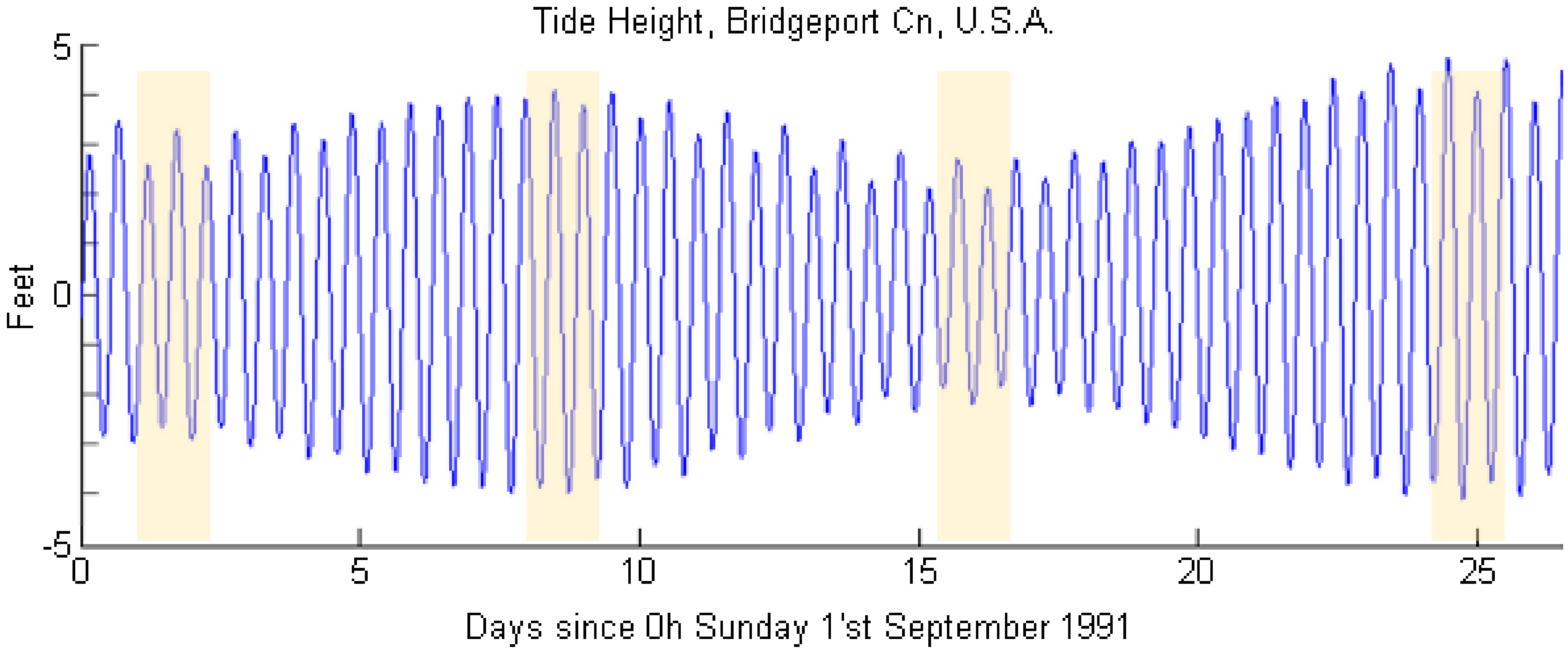
TIDE LEVELS



https://en.wikipedia.org/wiki/Tide

TIDE LEVELS

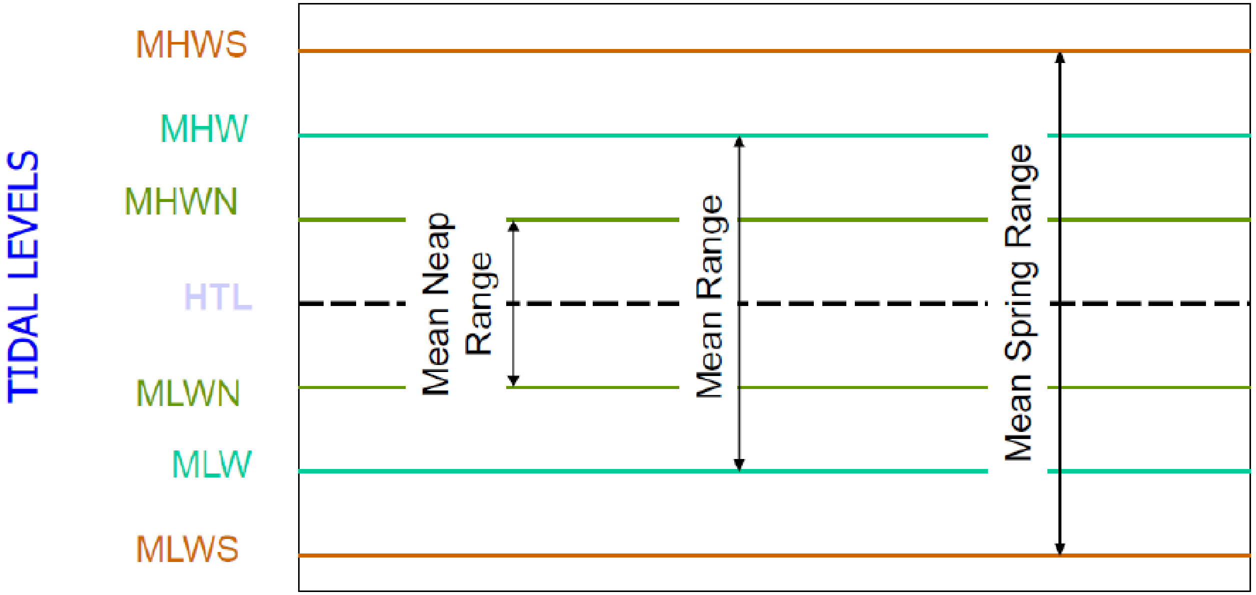
Term	Definition
High water/tide	Highest level reached at a place by the water surface in one tidal cycle
Low water/tide	Lowest level reached at a place by the water surface in one tidal cycle
Mean high water	The average of all the high water level at a place over a period
Mean low water	The average of all the low water level at a place over a period
Mean tide level/ half-tide level	Average of MHW and MLW within a certain period at a place
Mean water level (MWL)	The average of all hourly water level over the available period of record
Mean sea level (MSL)	Average height of the surface of sea at a tide station for all stages of tide over 19 years period, usually determined by hourly height reading measured from a fixed pre-determined reference level.



Tide Height, Bridgeport Cn, U.S.A.
Feet
5
0
-5
0
5
10
15
20
25
Days since 0h Sunday 1'st September 1991

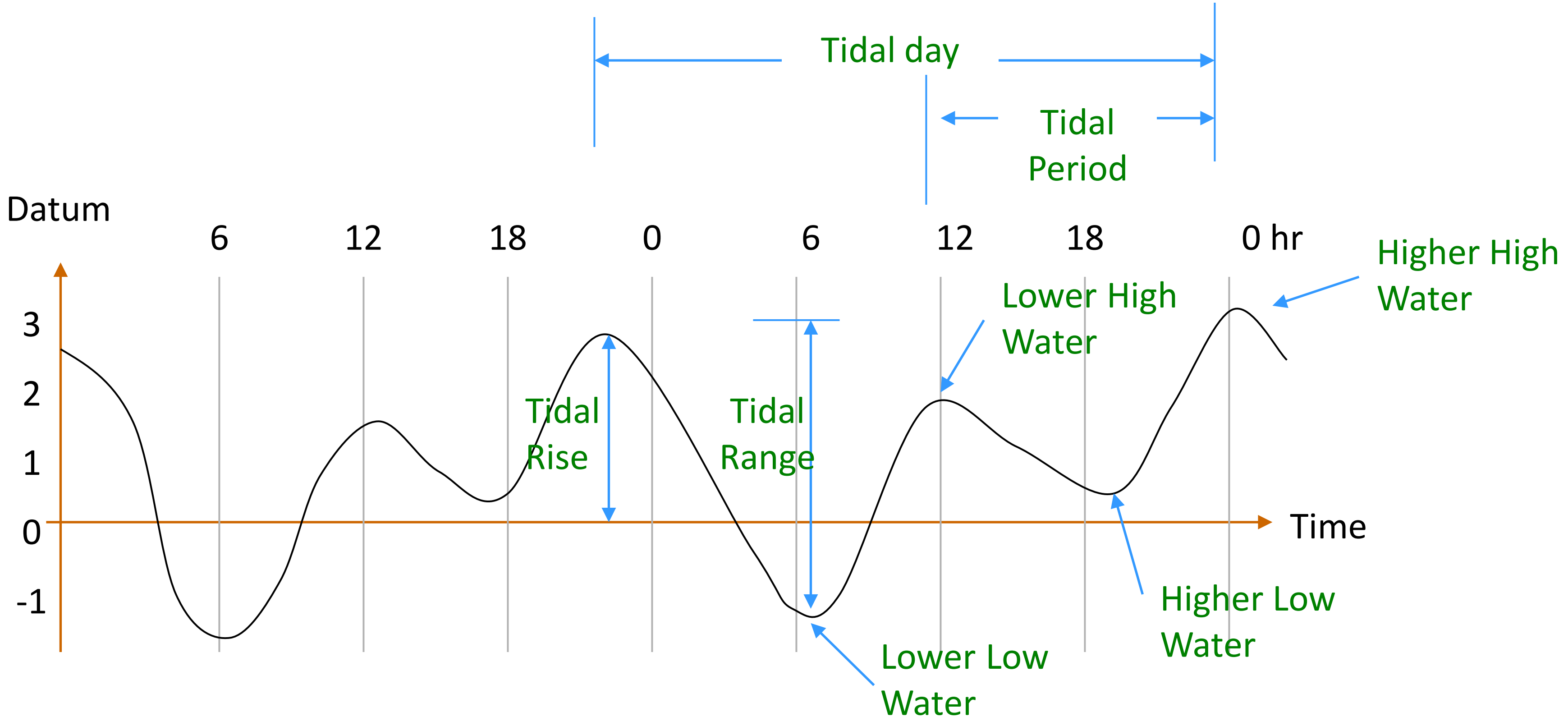
TIDE LEVELS

Term	Definition
Mean high water spring (MHWS)	Average height of the high waters of spring tides at a place over a period
Mean high water neap (MHWN)	Average height of the high waters of neap tides at a place over a period
Mean low water spring (MLWS)	Average height of the low waters of spring tides at a place over a period
Mean low water neap (MLWN)	Average height of the low waters of neap tides at a place over a period



* HTL – Half-tide level/ Amplitude

TIDE LEVELS



Term	Definition
Mean Higher High Water (MHHW)	Average height of higher high waters at a place over a 19-year period.
Mean Lower Low Water (MLLW)	Average height of lower low waters at a place over a 19-year period.

TIDE LEVELS

Term	Definition
Lowest Astronomical Tide (LAT)	The lowest tidal level which can be predicted to occur under average meteorological conditions and under any combination of astronomical condition
Highest Astronomical Tides (HAT)	The highest tidal level which can be predicted to occur under average meteorological conditions and under any combination of astronomical condition

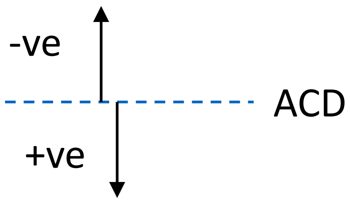
- LAT is commonly used for hydrographic charts to minimize the possibility of navigators running aground at low tide.
- Land elevations are usually referenced to MSL so care must be taken in combining topographic and hydrographic.

LEVEL CONVERSION

1. **Hydrographic chart**

   – Sounding depth (Bed levels measured below ACD)

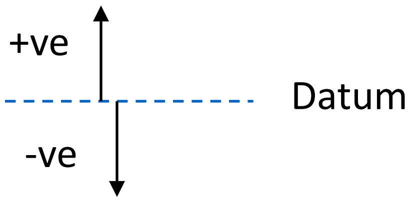
   "+" = below ACD ; "-" = above ACD



Hydrographical chart

2. **Land surveying chart**

   "+" = above LSD ; "-" = below LSD

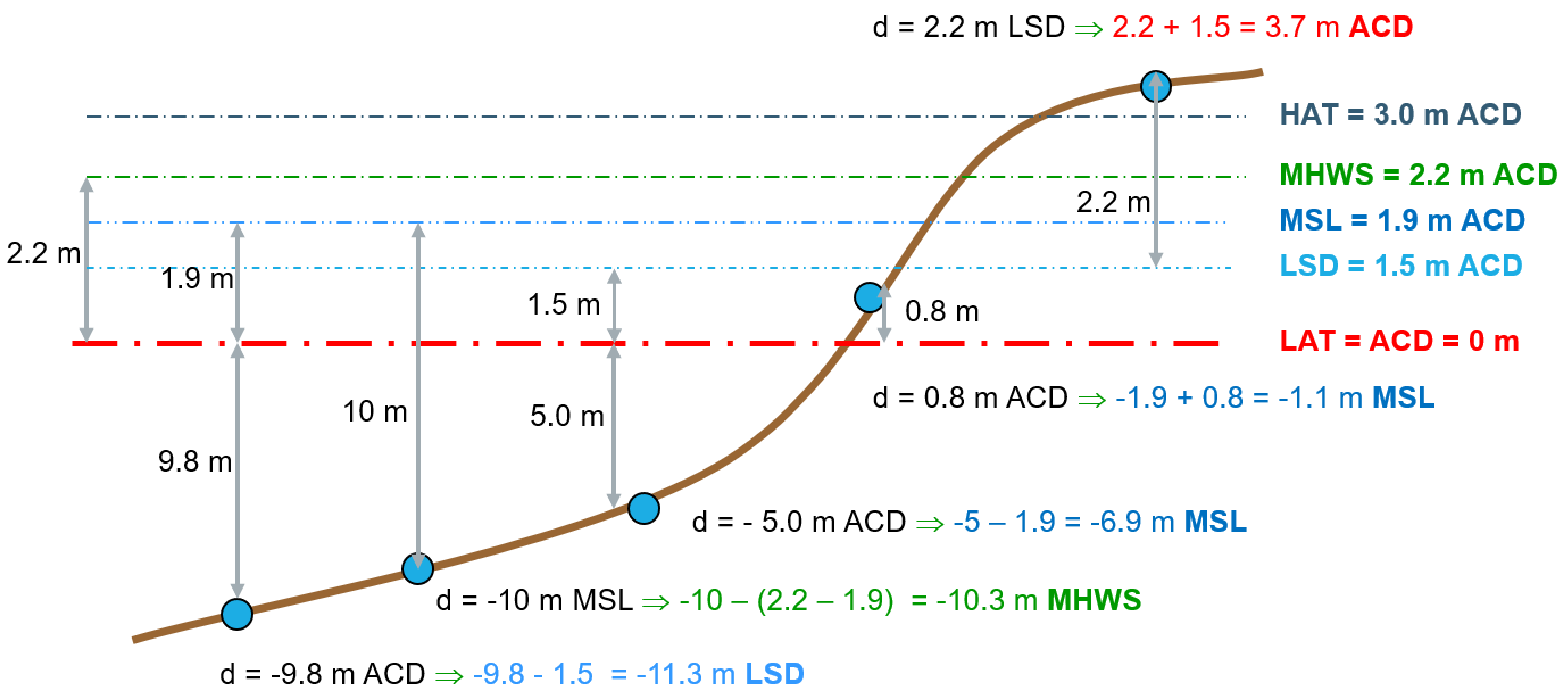


Land surveying chart

3. **Tide table**

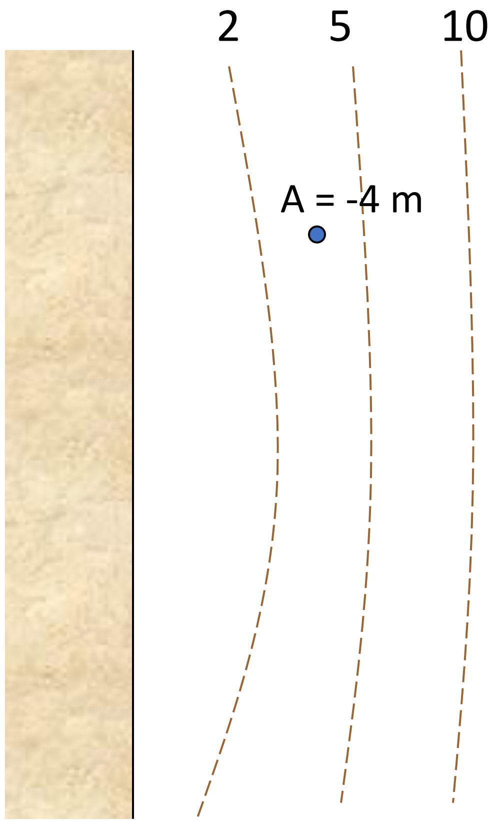
   "+" = above ACD

LEVEL CONVERSION



Land surveying chart

PROBLEM

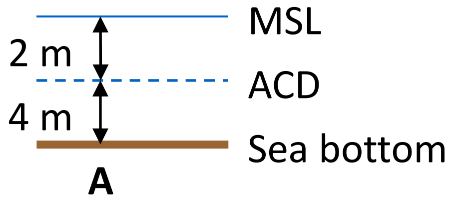


All levels in meters ACD

If MSL = 2 m above ACD, determine the water depth at A.

Solutions:

i. $d = 2 + 4 =$ **6 m**



PROBLEM

Tidal levels at Port Dickson:

LAT = 0.00 m ACD

MLWS = 0.26 m ACD

MLWN = 1.09 m ACD

MSL = 1.50 m ACD

MHWN = 1.91 m ACD

MHWS = 2.74 m ACD

HAT = 3.40 m ACD

Find:

a. MHW and MLW

b. Mean neap & mean spring ranges

c. Mean range

SOLUTIONS:

a. MHW = (1.91 + 2.74)/2 = 2.33 m ACD

MLW = (0.26 + 1.09)/2 = 0.68 m ACD

b. Mean neap range = 1.91 - 1.09 = 0.82 m

Mean spring range = 2.74 – 0.26 = 2.48 m

c. Mean range = 2.33 – 0.68 = 1.65 m

or (2.48 + 0.82)/2 = 1.65 m

Tide Prediction

- A long record (should be 19 years long) of the tide measured on a continuous basis by a **tide gauge** is needed to **analyzed** and then **predict the tide** at a particular location.
- The **tidal elevation η** above a selected datum can be given by

No. of components used

$$\eta = A + \sum_{i=1}^{N} A_i \cos\left(\frac{2\pi t}{T_i} + \Delta_i\right) \ldots$$

Time

Vertical distance from a datum

Amplitude

Period

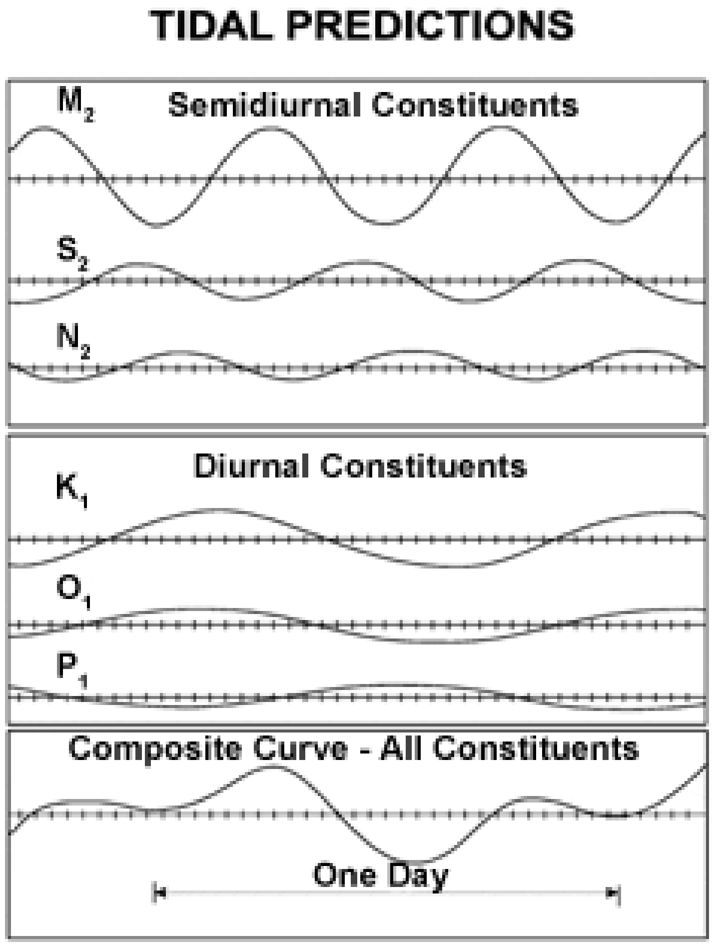
Phase angle

Tidal ratio determines the importance of diurnal and semi-diurnal harmonics.

$$F = \frac{K_1 + O_1}{M_2 + S_2}$$

Constituent	Description
K_1	Soli-Lunar constituent – Diurnal tides
O_1	Main-Lunar constituent – Diurnal tides
M_2	Main-Lunar constituent – Semi-diurnal tides
S_2	Main-Solar constituent – Semi-diurnal tides

F	Tidal form
0.00 – 0.25	Semi-diurnal tide
0.25 – 1.50	Mixed, Predominantly Semidiurnal tide
1.50 – 3.00	Mixed, Predominantly Diurnal tide
> 3.00	Diurnal tide



Maximum Tide Level: Summation of the tidal amplitudes of the tidal harmonics to the mean water level, Z_o.

Max tide level $= M_2 + S_2 + K_1 + O_1 + Z_o$

PROBLEM

Classify the form of tide at Harbour X.

Constituent	Period (h)	Amplitude (cm)
K_1	23.93	31
O_1	25.83	26
M_2	12.42	45
S_2	12.00	10

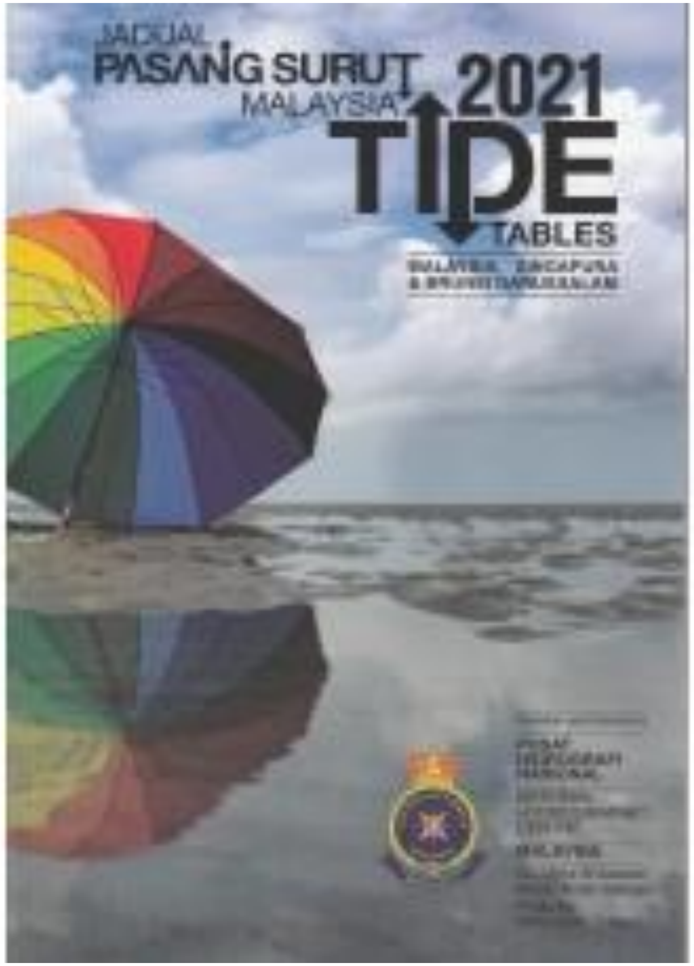
SOLUTION

Constituent	Period (h)	Amplitude (cm)
K_1	23.93	31
O_1	25.83	26
M_2	12.42	45
S_2	12.00	10

$$F = \frac{K_1+O_1}{M_2+S_2} = \frac{23.93+25.83}{12.42+12.00} = 2.04$$

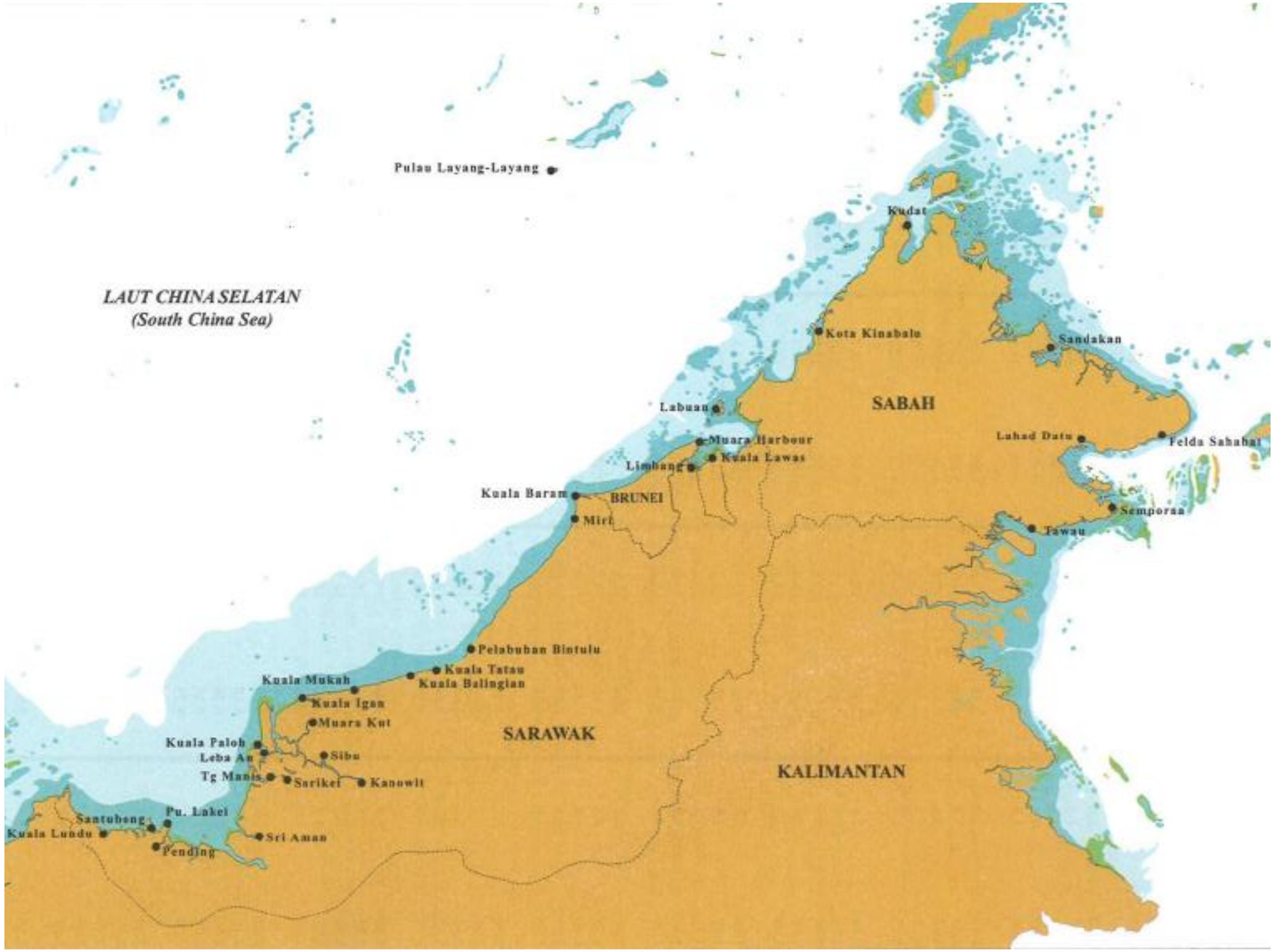
F	**Tidal form**
1.50 – 3.00	Mixed, Predominantly Diurnal tide

Tide Table



- The equation can be used to **predict future tide levels** at the location where the analyzed record is measured.
- The predicted results are published annually by National Hydrographic Centre for selected ports – **Tide Table**.
- Data are presented in terms of the elevation (Above Admiralty Chart Datum, ACD) and time of high and low tide levels.
- **Does not include meteorological effects** that may be active at a particular time.

Location of standard ports in Malaysia



TIDE TABLE

Pelabuhan Klang, Selangor Darul Ehsan

Tide Table April 2019

Date	Time	M	Date	Time	M	Date	Time	M	Date	Time	M
1	0404	3.7	9	0223	0.8	17	0424	4.5	25	0323	1.5
	1018	1.9		0814	4.7		1044	1.0		0915	4.1
	1621	4.1		1421	1.0		1654	5.0		1515	1.9
MON	2239	1.6	TUE	2034	4.9	WED	2321	1.0	THUR	2123	4.1
2	0441	4.1	10	0252	1.0	18	0516	4.8	26	0347	1.9
	1054	1.5		0843	4.5		1134	0.7		0947	3.9
	1657	4.4		1449	1.2		1741	5.3		1550	2.2
TUE	2315	1.4	WED	2103	4.6	THUR			FRI	2201	3.73
3	0513	4.3	11	0323	1.3	19	0008	0.7	27	0422	2.2
	1127	1.2		0915	4.3		0600	5.0		1042	3.6
	1731	4.7		1522	1.5		1216	0.5		1657	2.5
WED	2349	1.2	THUR	2135	4.3	FRI	1822	5.5	SAT	2319	3.3
4	0544	4.5	12	0400	1.6	20	0048	0.6	28	0533	2.5
	1158	0.9		0954	4.0		0639	5.0		1244	3.5
THUR	1803	4.9		1605	1.9		1253	0.5		2007	2.5
			FRI	2218	4.0	SAT	1858	5.5	SUN		
5	0022	1.0	13	0453	2.0	21	0125	0.5	29	0202	3.4
	0614	4.7		1100	3.8		0716	5.0		0819	2.5
	1229	0.7		1728	2.2		1327	0.7		1427	3.8
FRI	1834	5.0	SAT	2343	3.7	SUN	1932	5.4	MON	2117	2.2
6	0053	0.9	14	0635	2.2	22	0158	0.6	30	0314	3.6
	0643	4.8		1308	3.8		0751	4.9		0923	2.2
	1258	0.7		1942	2.2		1358	0.9		1528	4.1
SAT	1905	5.1	SUN			MON	2003	5.2	TUE	2201	1.8
7	0124	0.8	15	0202	3.7	23	0229	0.8			
	0715	4.8		0830	1.9		0822	4.7			
	1326	0.7		1445	4.1		1425	1.2			
SUN	1935	5.1	MON	2115	1.8	TUE	2031	4.8			
8	0153	0.8	16	0323	4.1	24	0256	1.1			
	0745	4.8		0946	1.5		0850	4.4			
	1353	0.8		1557	4.6		1450	1.6			
MON	2005	5.1	TUE	2224	1.4	WED	2056	4.5			

ARAS PASANG SURUT PELABUHAN PIAWAI
TIDAL LEVELS AT STANDARD PORT

Pelabuhan Piawai *Standard Port*	Air Surut Falak Terendah *Lowest Astronomical Tide*	Air Surut Perbani Min *Mean Low Water Spring*	Air Surut Anak Min *Mean Low Water Neap*	Aras Laut Min *Mean Sea Level*	Air Pasang Anak Min *Mean High Water Neap*	Air Pasang Perbani Min *Mean High Water Spring*	Air Pasang Falak Tertinggi *Highest Astronomical Tide*	Pihak Berkuasa (a) *Authority for (a)*			Tahun Cerapan (b) *Years of Tidal Observations (b)*
								Cerapan *Observations*	Pemalar *Constants*	Ramalan *Predictions*	
	m.	m.	m.	m.	m.	m.	m.				
Teluk Ewa	0.00	0.56	1.46	1.82	2.18	3.07	3.56	DSM	RMN	RMN	1991 - 04 (13)
Kuah	0.00	0.53	1.33	1.64	1.94	2.74	3.26	RMN	RMN	RMN	2005 - 09 (4)
Kuala Perlis	0.00	0.56	1.40	1.68	1.96	2.80	3.69	RMN	RMN	RMN	2005 (6 mths)
Kedah Pier, Pulau Pinang	0.00	0.72	1.45	1.71	1.96	2.69	3.09	DSM	RMN	RMN	1989 - 03 (13)
Butterworth	0.00	0.77	1.48	1.72	1.96	2.67	3.06	RMN	RMN	RMN	2004 - 06 (17 mths)
Kuala Sepetang	0.00	0.82	1.45	1.76	2.06	2.69	2.96	RMN	RMN	RMN	2010 – 11 (18 mths)
Lumut	0.00	0.75	1.45	1.85	2.24	2.94	3.45	DSM	RMN	RMN	1989 - 03 (13)
Bagan Datuk	0.00	0.52	1.25	1.72	2.20	2.93	3.48	RMN	RMN	RMN	2009 - 11 (2)
Pelabuhan Klang	0.00	0.98	2.35	3.03	3.72	5.09	5.82	DSM	RMN	RMN	1992 - 05 (13)
Permatang Sedepa	0.00	0.85	2.08	2.71	3.34	4.57	5.31	ITS	ITS	RMN	1979 (1)
Port Dickson	0.00	0.31	1.14	1.55	1.96	2.79	3.51	ITS	ITS	RMN	1979 (1)
Kuala Linggi	0.00	0.31	0.96	1.29	1.61	2.27	2.91	RMN	RMN	RMN	2007 - 09 (17 mths)
Tanjung Keling	0.00	0.29	0.88	1.19	1.51	2.10	2.65	DSM	RMN	RMN	1991 - 02 (11)
Kuala Batu Pahat	0.00	0.43	1.15	1.59	2.03	2.75	3.37	ITS	ITS	RMN	1979 (1)
Pulau Pisang	0.00	0.42	1.26	1.77	2.28	3.12	3.79	ITS	ITS	RMN	1979 (1)
Kukup	0.00	0.37	1.21	1.70	2.20	3.04	3.68	DSM	RMN	RMN	1989 - 03 (13)
Tanjung Pelepas	0.00	0.30	1.17	1.66	2.16	3.03	3.75	RMN	RMN	RMN	2004 - 05 (14 mths)
Johor Bahru	0.00	0.99	1.67	2.20	2.73	3.41	4.00	DSM	RMN	RMN	1990 - 03 (13)
Pasir Gudang	0.00	0.92	1.56	2.05	2.54	3.18	3.62	RMN	RMN	RMN	1989 (1)
Tanjung Langsat	0.00	0.93	1.56	2.07	2.58	3.20	3.71	RMN	RMN	RMN	2010 - 13 (3)
Sungai Belungkor	0.00	0.99	1.61	2.11	2.60	3.22	3.86	RMN	RMN	RMN	2004 - 05 (1)

HOURLY TIDAL DATA

KUAH, PULAU LANGKAWI, KEDAH DARUL AMAN

YEAR 2014

Lat 06 18 N   Long 099 51 E

TIME ZONE -0800

MARCH

HEIGHTS IN METRES

Hour	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 Sa	2.9	2.8	2.4	1.8	1.2	0.6	0.2	0.2	0.4	0.9	1.5	2.2	2.6	2.7	2.5	2.0	1.5	0.9	0.6	0.4	0.6	1.0	1.6	2.3
2 Su	2.8	3.0	2.7	2.2	1.6	0.9	0.4	0.1	0.2	0.5	1.1	1.8	2.5	2.8	2.7	2.4	1.9	1.3	0.7	0.4	0.4	0.7	1.2	1.9
3 M	2.5	2.9	2.9	2.6	2.0	1.3	0.7	0.3	0.1	0.3	0.8	1.4	2.1	2.7	2.8	2.6	2.2	1.6	1.0	0.6	0.4	0.5	0.8	1.4
4 T	2.1	2.6	2.9	2.7	2.3	1.7	1.0	0.5	0.2	0.3	0.6	1.1	1.8	2.4	2.8	2.7	2.4	1.9	1.4	0.9	0.5	0.5	0.7	1.1
5 W	1.7	2.2	2.6	2.7	2.4	1.9	1.3	0.8	0.5	0.4	0.5	0.9	1.5	2.1	2.5	2.7	2.5	2.1	1.6	1.1	0.8	0.6	0.7	1.0
6 Th	1.4	1.9	2.3	2.5	2.4	2.0	1.6	1.1	0.7	0.6	0.6	0.9	1.3	1.8	2.2	2.5	2.5	2.2	1.8	1.4	1.0	0.8	0.8	0.9
7 F	1.2	1.6	1.9	2.2	2.2	2.0	1.7	1.3	1.0	0.8	0.8	0.9	1.2	1.6	2.0	2.2	2.3	2.2	1.9	1.6	1.3	1.0	1.0	1.0
8 Sa	1.2	1.4	1.7	1.9	1.9	1.9	1.7	1.5	1.2	1.0	1.0	1.1	1.2	1.5	1.7	1.9	2.1	2.1	1.9	1.7	1.5	1.3	1.2	1.2
9 Su	1.2	1.3	1.5	1.6	1.7	1.7	1.7	1.5	1.4	1.3	1.2	1.2	1.3	1.4	1.6	1.7	1.8	1.9	1.8	1.8	1.7	1.5	1.4	1.4
10 M	1.3	1.3	1.3	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.7	1.7	1.6
11 T	1.5	1.4	1.3	1.2	1.2	1.2	1.3	1.4	1.6	1.7	1.7	1.7	1.6	1.5	1.4	1.3	1.3	1.4	1.5	1.6	1.8	1.9	1.9	1.9
12 W	1.7	1.5	1.3	1.1	1.0	1.0	1.1	1.3	1.5	1.7	1.9	1.9	1.8	1.6	1.4	1.3	1.2	1.2	1.3	1.4	1.7	1.9	2.1	2.1
13 Th	2.0	1.7	1.4	1.1	0.9	0.8	0.9	1.1	1.4	1.7	2.0	2.1	2.1	1.9	1.6	1.3	1.1	1.0	1.0	1.2	1.5	1.9	2.2	2.3
14 F	2.3	2.0	1.6	1.2	0.9	0.7	0.7	0.8	1.2	1.6	2.0	2.2	2.3	2.1	1.8	1.4	1.1	0.9	0.8	1.0	1.3	1.7	2.2	2.4
15 Sa	2.5	2.3	1.9	1.4	1.0	0.7	0.5	0.6	0.9	1.4	1.9	2.3	2.5	2.4	2.1	1.6	1.2	0.9	0.7	0.8	1.1	1.5	2.0	2.4
16 Su	2.6	2.6	2.2	1.7	1.2	0.7	0.5	0.5	0.7	1.1	1.7	2.2	2.5	2.6	2.3	1.9	1.4	1.0	0.7	0.6	0.8	1.2	1.7	2.3
17 M	2.6	2.7	2.5	2.0	1.5	0.9	0.5	0.4	0.5	0.9	1.4	2.0	2.5	2.7	2.6	2.2	1.7	1.2	0.7	0.5	0.6	0.9	1.4	2.0
18 T	2.5	2.8	2.7	2.3	1.7	1.2	0.7	0.4	0.4	0.7	1.2	1.8	2.4	2.7	2.8	2.5	2.0	1.4	0.9	0.6	0.5	0.7	1.1	1.7
19 W	2.3	2.7	2.7	2.5	2.0	1.4	0.9	0.5	0.4	0.5	0.9	1.5	2.1	2.6	2.8	2.7	2.3	1.7	1.2	0.7	0.5	0.6	0.9	1.4
20 Th	2.0	2.5	2.7	2.6	2.2	1.7	1.1	0.7	0.4	0.5	0.8	1.3	1.9	2.4	2.8	2.7	2.5	2.0	1.4	0.9	0.6	0.6	0.7	1.1
21 F	1.6	2.1	2.5	2.5	2.3	1.9	1.4	0.9	0.6	0.5	0.7	1.1	1.6	2.1	2.5	2.7	2.5	2.2	1.7	1.2	0.9	0.7	0.7	1.0
22 Sa	1.4	1.8	2.2	2.4	2.3	2.0	1.6	1.2	0.9	0.7	0.8	1.0	1.4	1.8	2.2	2.5	2.5	2.3	1.9	1.5	1.1	0.9	0.8	1.0
23 Su	1.2	1.5	1.8	2.1	2.1	2.0	1.8	1.5	1.2	1.0	0.9	1.0	1.3	1.6	1.9	2.2	2.3	2.3	2.1	1.8	1.5	1.2	1.1	1.0
24 M	1.1	1.3	1.5	1.7	1.9	1.9	1.8	1.7	1.5	1.3	1.2	1.2	1.2	1.4	1.6	1.8	2.0	2.1	2.1	2.0	1.8	1.5	1.4	1.2
25 T	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.7	1.7	1.6	1.5	1.4	1.4	1.4	1.4	1.5	1.7	1.8	2.0	2.0	2.0	1.9	1.7	1.5
26 W	1.4	1.2	1.1	1.1	1.2	1.3	1.5	1.7	1.8	1.9	1.8	1.7	1.6	1.4	1.3	1.3	1.3	1.5	1.7	1.9	2.1	2.2	2.1	1.9
27 Th	1.7	1.4	1.1	0.9	0.9	0.9	1.1	1.4	1.8	2.0	2.2	2.1	1.9	1.7	1.4	1.2	1.1	1.1	1.3	1.6	1.9	2.2	2.4	2.4
28 F	2.1	1.7	1.3	1.0	0.7	0.6	0.7	1.1	1.5	2.0	2.3	2.4	2.3	2.1	1.7	1.3	1.0	0.8	0.9	1.2	1.6	2.1	2.5	2.6
29 Sa	2.5	2.2	1.7	1.2	0.7	0.5	0.4	0.7	1.1	1.7	2.2	2.6	2.7	2.5	2.1	1.6	1.1	0.7	0.6	0.8	1.1	1.7	2.2	2.7
30 Su	2.8	2.6	2.1	1.6	1.0	0.6	0.3	0.4	0.7	1.3	1.9	2.5	2.8	2.8	2.5	2.0	1.4	0.9	0.6	0.5	0.8	1.2	1.8	2.4
31 M	2.8	2.8	2.5	2.0	1.4	0.8	0.4	0.3	0.5	0.9	1.6	2.3	2.8	2.9	2.7	2.3	1.7	1.1	0.7	0.4	0.5	0.9	1.4	2.1

KUAH, PULAU LANGKAWI, KEDAH DARUL AMAN

Lat 06 18 N   Long 099 51 E

TIME ZONE -0800   TIMES AND HEIGHTS OF HIGH AND LOW WATERS   2014

JANUARY

Day	Time	m	Day	Time	m
1 W	0635 1225 1831	0.3 2.4 0.5	16 Th	0026 0700 1254 1846	2.6 0.4 2.3 0.6
2 Th	0036 0720 1311 1918	3.0 0.2 2.5 0.5	17 F	0057 0728 1324 1916	2.7 0.4 2.3 0.6
3 F	0119 0803 1354 2003	3.0 0.1 2.6 0.5	18 Sa	0126 0755 1353 1946	2.7 0.4 2.4 0.6
4 Sa	0200 0843 1437 2044	3.0 0.2 2.6 0.6	19 Su	0153 0822 1420 2015	2.7 0.4 2.4 0.6
5 Su	0239 0920 1518 2123	2.9 0.2 2.5 0.7	20 M	0220 0847 1448 2045	2.7 0.4 2.4 0.7
6 M	0319 0954 1600 2201	2.7 0.4 2.4 0.9	21 T	0246 0912 1517 2115	2.6 0.4 2.3 0.8
7 T	0357 1025 1643 2240	2.5 0.6 2.2 1.0	22 W	0314 0938 1549 2148	2.4 0.5 2.3 0.9
8 W	0438 1057 1734 2332	2.2 0.8 2.1 1.2	23 Th	0345 1007 1628 2227	2.3 0.7 2.2 1.0
9 Th	0528 1139 1843	1.9 1.0 2.0	24 F	0423 1042 1722 2328	2.0 0.8 2.1 1.1
10 F	0109 0653 1254 2017	1.3 1.7 1.1 2.0	25 Sa	0523 1140 1842	1.8 1.0 2.0
11 Sa	0338 0858 1454 2137	1.2 1.6 1.1 2.1	26 Su	0119 0713 1325 2025	1.2 1.7 1.1 2.0
12 Su	0444 1020 1612 2233	1.0 1.8 1.0 2.2	27 M	0333 0918 1521 2150	1.0 1.7 1.0 2.2
13 M	0525 1109 1701 2316	0.8 1.9 0.9 2.4	28 T	0444 1037 1637 2251	0.8 2.0 0.8 2.5
14 T	0559 1149 1740 2353	0.7 2.1 0.8 2.5	29 W	0538 1132 1735 2340	0.5 2.2 0.6 2.7
15 W	0630 1223 1814	0.5 2.2 0.7	30 Th	0624 1219 1825	0.3 2.4 0.5
			31 F	0025 0708 1302 1911	2.9 0.1 2.5 0.4

FEBRUARY

Day	Time	m	Day	Time	m
1 Sa	0108 0749 1342 1954	3.0 0.0 2.6 0.4	16 Su	0107 0734 1332 1934	2.7 0.3 2.5 0.5
2 Su	0147 0825 1420 2033	3.0 0.0 2.7 0.4	17 M	0135 0800 1358 2004	2.7 0.3 2.5 0.5
3 M	0224 0858 1455 2108	2.9 0.1 2.6 0.5	18 T	0201 0825 1424 2033	2.7 0.3 2.6 0.5
4 T	0259 0926 1530 2139	2.7 0.3 2.5 0.7	19 W	0228 0851 1453 2102	2.6 0.3 2.5 0.6
5 W	0333 0951 1604 2208	2.5 0.5 2.3 0.8	20 Th	0256 0914 1522 2131	2.5 0.4 2.5 0.7
6 Th	0407 1012 1640 2241	2.2 0.7 2.2 1.0	21 F	0327 0938 1555 2204	2.3 0.6 2.3 0.9
7 F	0443 1037 1726 2335	1.9 0.9 2.0 1.2	22 Sa	0403 1008 1638 2253	2.1 0.8 2.2 1.0
8 Sa	0540 1119 1854	1.6 1.1 1.8	23 Su	0453 1054 1746	1.8 1.0 2.0
9 Su	0251 0819 1345 2108	1.2 1.5 1.3 1.8	24 M	0029 0640 1238 1945	1.1 1.6 1.2 1.9
10 M	0434 1013 1603 2219	1.1 1.6 1.1 2.0	25 T	0312 0914 1510 2134	1.0 1.7 1.1 2.1
11 T	0512 1101 1653 2302	0.9 1.8 1.0 2.2	26 W	0429 1032 1631 2238	0.8 2.0 0.9 2.4
12 W	0542 1136 1729 2338	0.7 2.0 0.8 2.4	27 Th	0521 1123 1727 2326	0.5 2.3 0.7 2.6
13 Th	0610 1207 1802	0.5 2.2 0.7	28 F	0606 1206 1815	0.3 2.5 0.5
14 F	0009 0639 1237 1833	2.5 0.4 2.3 0.6			
15 Sa	0038 0707 1305 1904	2.6 0.3 2.4 0.5			

MARCH

Day	Time	m	Day	Time	m
1 Sa	0010 0647 1245 1859	2.8 0.1 2.7 0.4	16 Su	0012 0636 1238 1846	2.6 0.4 2.6 0.6
2 Su	0051 0725 1322 1938	2.9 0.0 2.8 0.3	17 M	0042 0705 1306 1917	2.7 0.3 2.7 0.5
3 M	0127 0800 1355 2015	2.9 0.1 2.8 0.3	18 T	0111 0733 1333 1949	2.7 0.3 2.7 0.4
4 T	0203 0830 1427 2047	2.8 0.2 2.8 0.4	19 W	0140 0801 1400 2019	2.7 0.3 2.8 0.5
5 W	0237 0855 1458 2115	2.6 0.3 2.6 0.6	20 Th	0210 0827 1429 2049	2.6 0.4 2.7 0.5
6 Th	0308 0916 1527 2139	2.4 0.5 2.5 0.7	21 F	0241 0853 1500 2120	2.5 0.5 2.6 0.6
7 F	0338 0934 1555 2205	2.2 0.7 2.3 0.9	22 Sa	0314 0919 1533 2153	2.3 0.7 2.5 0.8
8 Sa	0409 0953 1627 2241	1.9 0.9 2.0 1.1	23 Su	0353 0949 1614 2240	2.1 0.9 2.3 1.0
9 Su	0453 1022 1722	1.7 1.2 1.8	24 M	0449 1035 1716	1.9 1.1 2.1
10 M	0025 0713 1153 2010	1.3 1.5 1.4 1.7	25 T	0015 0643 1224 1914	1.1 1.7 1.3 2.0
11 T	0356 0957 1545 2153	1.1 1.6 1.3 1.9	26 W	0249 0908 1505 2113	1.0 1.8 1.2 2.1
12 W	0439 1041 1637 2238	0.9 1.9 1.1 2.1	27 Th	0404 1017 1621 2218	0.8 2.1 1.0 2.4
13 Th	0509 1113 1710 2311	0.8 2.1 0.9 2.3	28 F	0454 1103 1714 2307	0.6 2.4 0.8 2.6
14 F	0538 1141 1742 2342	0.6 2.3 0.8 2.5	29 Sa	0538 1143 1800 2350	0.4 2.6 0.6 2.7
15 Sa	0608 1209 1813	0.5 2.4 0.7	30 Su	0618 1221 1841	0.3 2.8 0.4
			31 M	0029 0655 1255 1920	2.8 0.2 2.9 0.4

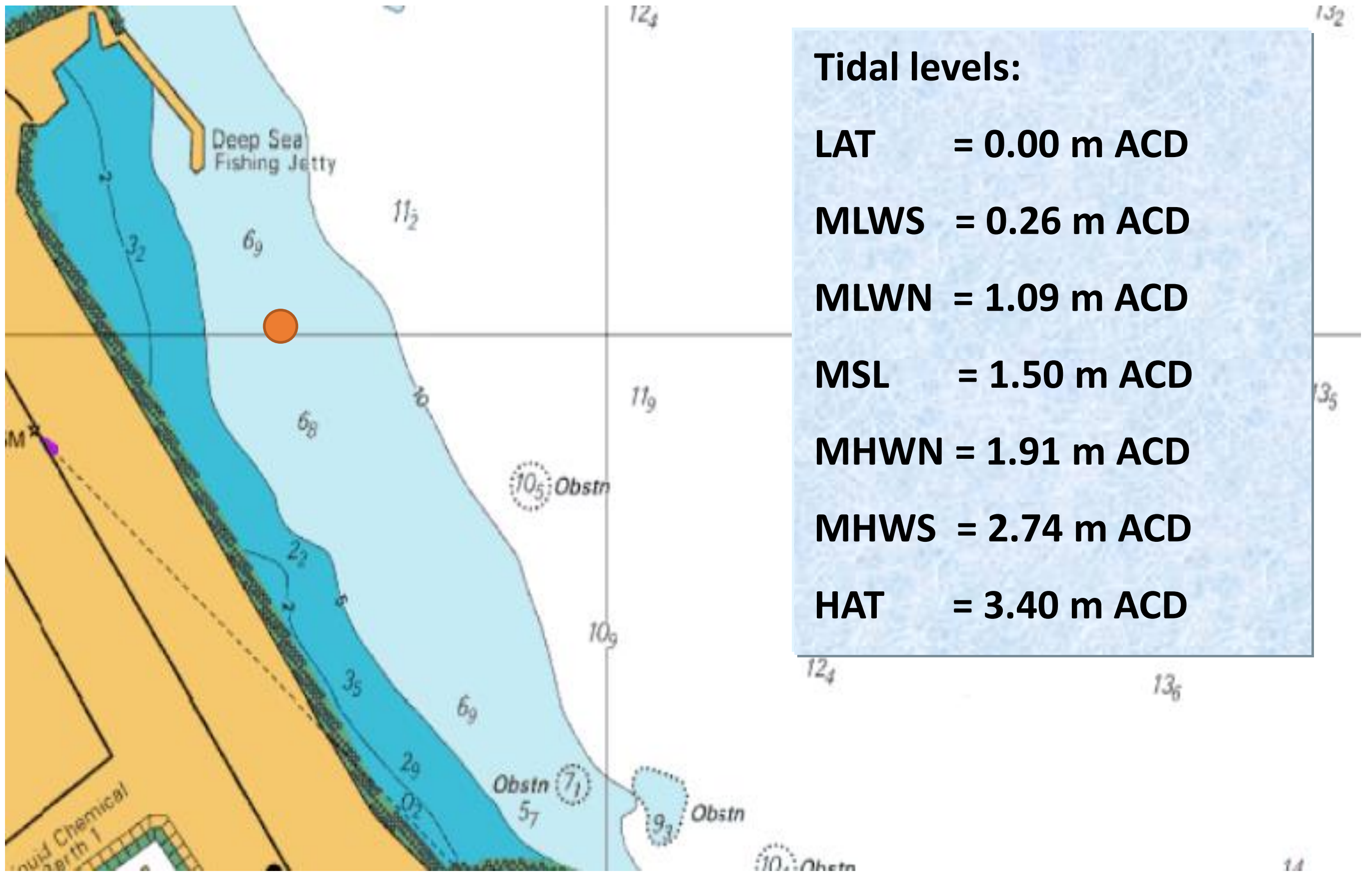
APRIL

Day	Time	m	Day	Time	m
1 T	0106 0729 1328 1954	2.8 0.3 2.9 0.4	16 W	0047 0704 1307 1933	2.7 0.4 2.9 0.5
2 W	0140 0758 1359 2025	2.7 0.4 2.9 0.5	17 Th	0121 0736 1338 2007	2.7 0.4 3.0 0.5
3 Th	0213 0823 1428 2052	2.6 0.5 2.8 0.6	18 F	0154 0808 1410 2040	2.6 0.5 2.9 0.5
4 F	0244 0844 1456 2116	2.4 0.7 2.6 0.7	19 Sa	0231 0838 1445 2115	2.5 0.6 2.8 0.6
5 Sa	0315 0904 1523 2140	2.2 0.8 2.4 0.9	20 Su	0309 0909 1523 2154	2.4 0.8 2.6 0.8
6 Su	0347 0925 1551 2214	2.0 1.0 2.2 1.1	21 M	0356 0946 1606 2246	2.2 1.0 2.4 1.0
7 M	0431 0954 1629 2321	1.8 1.2 2.0 1.2	22 T	0501 1040 1707	2.0 1.3 2.2
8 T	0611 1101 1807	1.6 1.4 1.8	23 W	0011 0651 1228 1847	1.1 1.9 1.4 2.1
9 W	0224 0906 1444 2052	1.3 1.7 1.5 1.8	24 Th	0210 0842 1446 2039	1.1 2.0 1.3 2.1
10 Th	0340 1003 1600 2154	1.1 1.9 1.3 2.0	25 F	0326 0948 1603 2150	0.9 2.3 1.1 2.3
11 F	0421 1037 1640 2234	0.9 2.2 1.1 2.2	26 Sa	0420 1035 1655 2242	0.7 2.5 0.9 2.5
12 Sa	0454 1106 1715 2308	0.8 2.4 0.9 2.4	27 Su	0505 1115 1741 2326	0.6 2.7 0.7 2.6
13 Su	0526 1135 1749 2340	0.6 2.5 0.8 2.5	28 M	0546 1153 1823	0.5 2.8 0.6
14 M	0559 1205 1823	0.5 2.7 0.6	29 T	0008 0623 1228 1900	2.6 0.5 2.9 0.5
15 T	0014 0631 1236 1858	2.6 0.5 2.8 0.5	30 W	0045 0657 1302 1935	2.6 0.5 2.9 0.5

APRIL

Day	Time	m	Day	Time	m
1 T	0106 0729 1328 1954	2.8 0.3 2.9 0.4	16 W	0047 0704 1307 1933	2.7 0.4 2.9 0.5

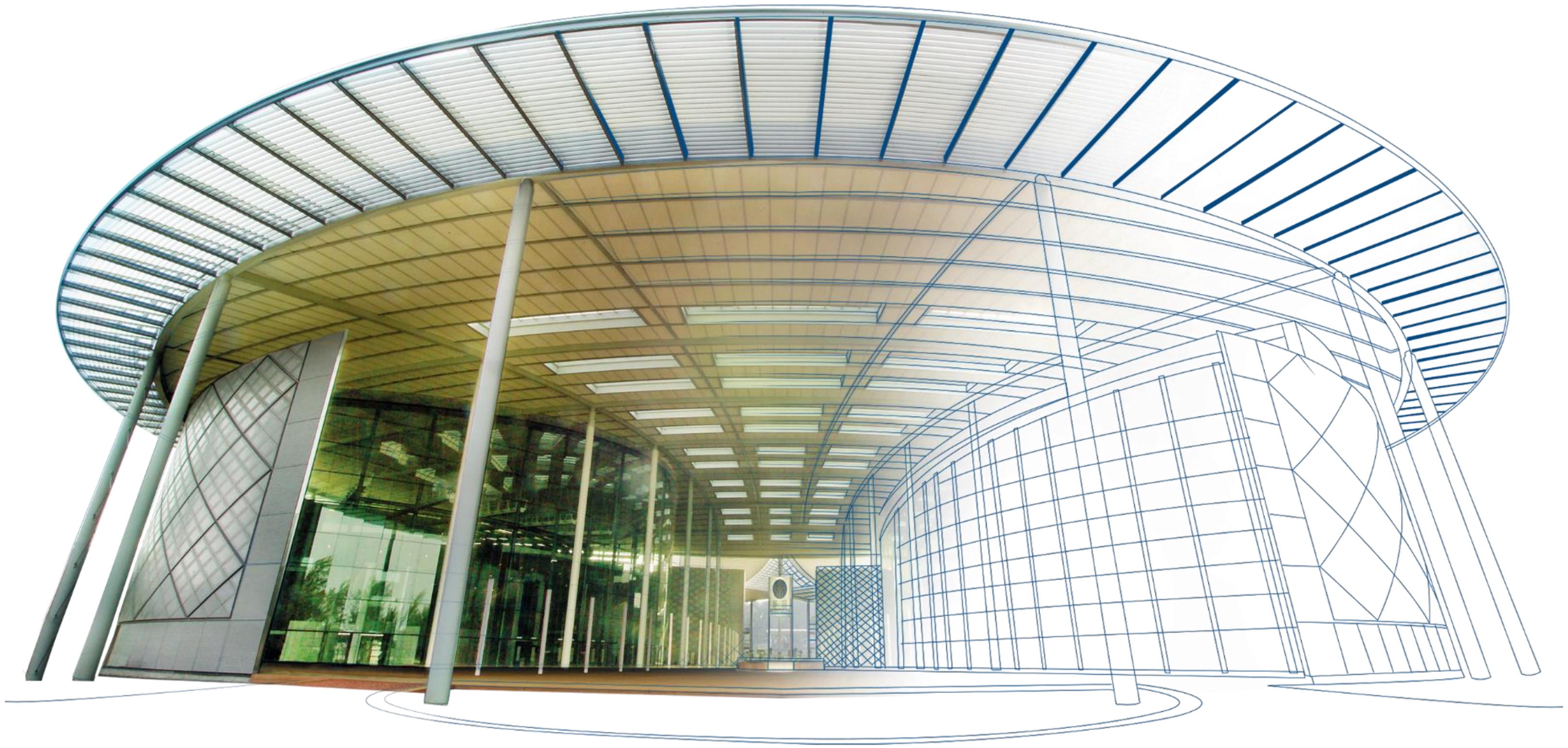
Problem



Tidal levels:

LAT	**= 0.00 m ACD**
MLWS	**= 0.26 m ACD**
MLWN	**= 1.09 m ACD**
MSL	**= 1.50 m ACD**
MHWN	**= 1.91 m ACD**
MHWS	**= 2.74 m ACD**
HAT	**= 3.40 m ACD**

What is the water depth at ?



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