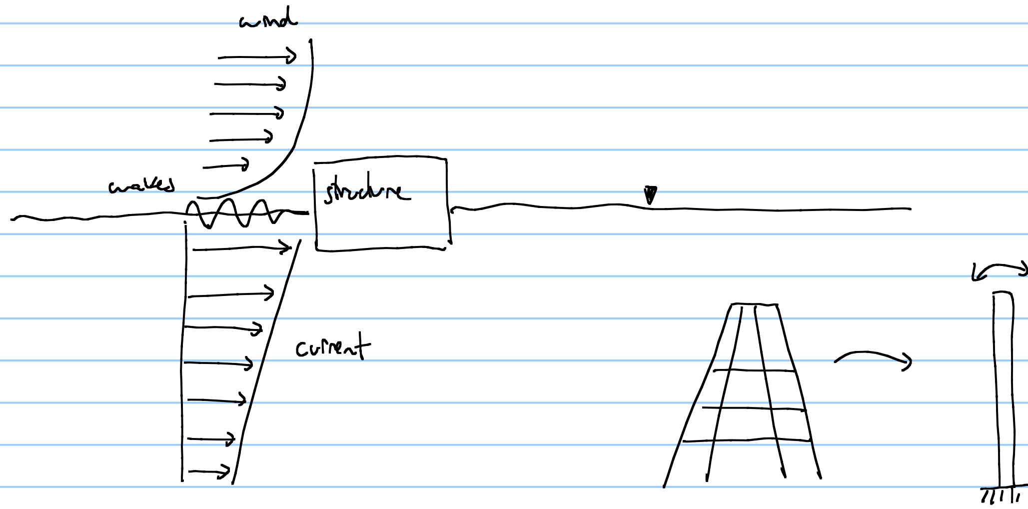
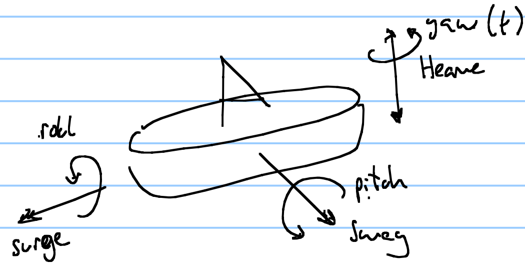
- Offshore structures for oil and gas production (cont)
- Excercise set 4

- storage capacity of offshore structure
  - accessibility
  - rough weather
  - political issues

  - FPSO 1E6 stb - 3E06 stb
  - GBS 150000 - 300000 stb
  - SPAR 150 000 stb

- Marine loads on offshore structure



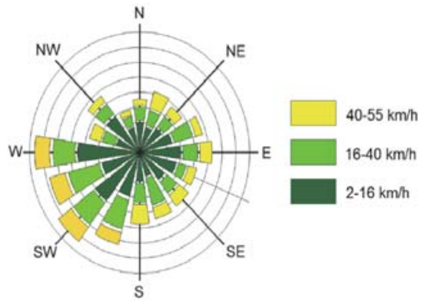


forces/marine loads on structure (t) → structure → movement (t)
→ stresses
  - maximum stress
  - long term (fatigue)

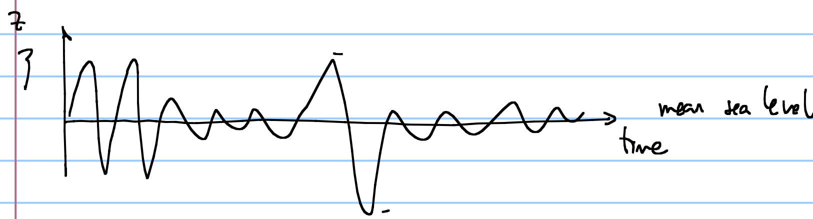
- magnitude
- frequency

wind
current
→ waves

e direction of wind a fixed value is typically used for design



o current a fixed value is typically used for design. Variation with depth is important



Fourier

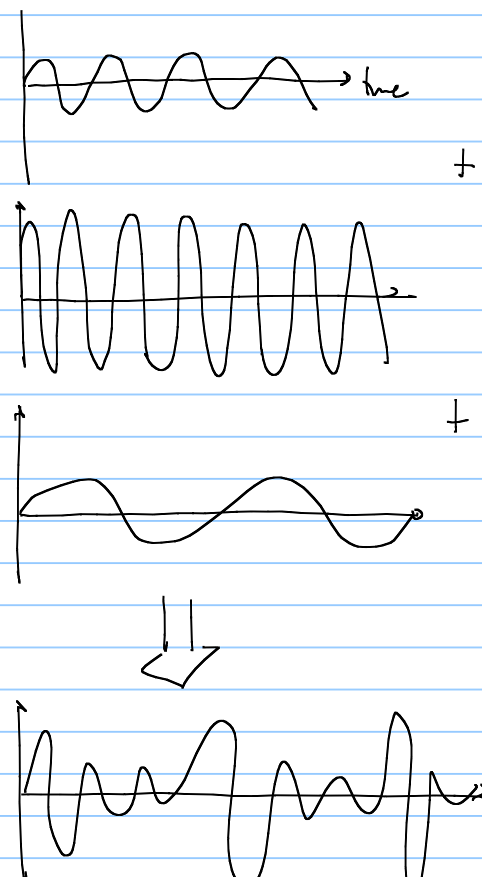
$$f(t) = \sum_{i=1}^{N} A_i \sin(\omega_i t + \delta_i)$$

angular frequency

amplitude (m)

$\omega_i = f_i \cdot 2\pi$

frequency



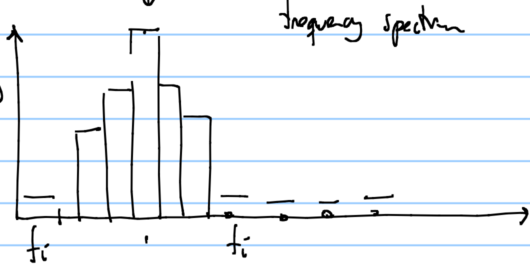
FFT fast-fourier transform

dominant frequency (spectral peak period $T_s = \frac{1}{f}$)

frequency spectrum

elevation

$f(t) \rightarrow$ FFT $\rightarrow$ spectral energy

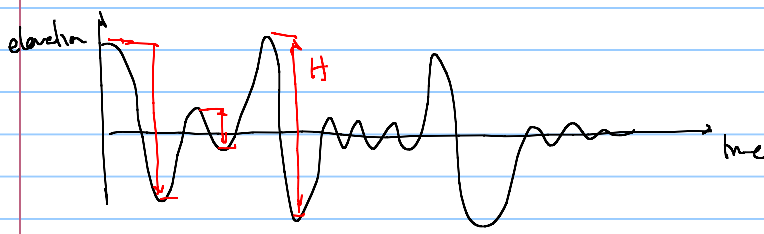


$\eta_i = \sqrt{2 \cdot S_i \cdot \Delta\omega_i}$

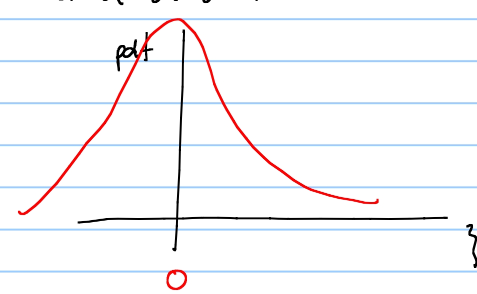
spectral energy

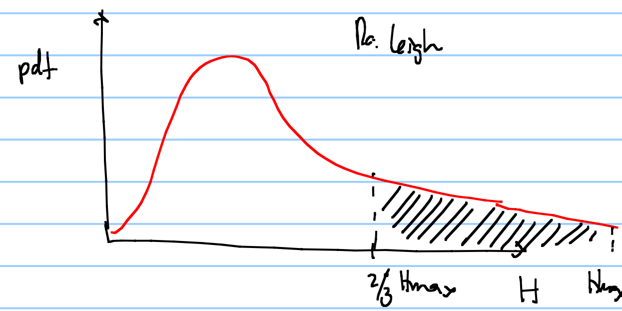
An assumption is made that T_s is relatively constant for a "sea-state" (3hrs)

in terms of magnitude instead of elevation, we use wave height



In a sea state ζ display a normal distribution





significant wave height H_s mean of Height in the Range $H_{max} \rightarrow \frac{2}{3} H_{max}$

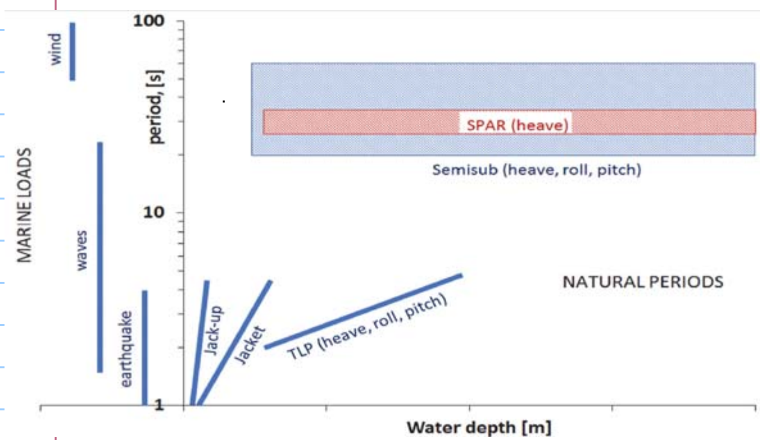
Typically we have to measure wave elevation data for about 2 years of area

$$N° \text{ sea states} = 2 \cdot \frac{24 \cdot 365}{3} = 5840$$

	Spectral Peak period (T_p) [s]																								
Hs [m]	0-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	24-25	Sum
0-1	15	290	1367	2876	3716	3527	2734	1849	1138	656	362	192	101	52	26	13	7	3	2	1	0	0	0	18927
1-2	1	81	1153	5308	12083	17323	18143	15262	10980	7053	4169	2316	1229	631	315	155	75	36	17	8	4	5	1	96348
2-3	0	2	94	1050	4532	10304	15020	15953	13457	9752	5991	3403	1795	894	426	197	88	39	17	7	3	1	1	83026
3-4	0	0	2	72	686	2782	6171	8847	9189	7493	5082	2991	1577	762	345	148	61	24	9	4	1	0	0	46246
4-5	0	0	0	2	51	433	1645	3495	4807	4750	3638	2286	1229	584	251	100	37	13	5	1	0	0	0	23327
5-6	0	0	0	0	2	39	294	1037	2069	2664	2440	1709	968	463	193	72	25	8	2	1	0	0	0	11986
6-7	0	0	0	0	0	2	32	215	692	1264	1485	1228	767	382	159	57	18	5	1	0	0	0	0	6307
7-8	0	0	0	0	0	0	2	27	157	447	730	762	555	302	130	46	14	4	1	0	0	0	0	3177
8-9	0	0	0	0	0	0	0	2	23	112	276	392	355	223	104	38	11	3	1	0	0	0	0	1540
9-10	0	0	0	0	0	0	0	0	2	19	77	160	192	148	79	31	9	2	0	0	0	0	0	719
10-11	0	0	0	0	0	0	0	0	0	2	16	50	85	85	55	24	8	2	0	0	0	0	0	327
11-12	0	0	0	0	0	0	0	0	0	0	2	12	29	40	33	18	7	2	0	0	0	0	0	143
12-13	0	0	0	0	0	0	0	0	0	0	0	2	8	15	17	12	5	2	0	0	0	0	0	61
13-14	0	0	0	0	0	0	0	0	0	0	0	0	2	5	7	6	4	1	0	0	0	0	0	25
14-15	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	2	1	0	0	0	0	0	9
15-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	4
16-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	16	373	2616	9308	21070	34410	44041	46687	42514	34212	24268	15503	8892	4587	2143	921	372	146	55	22	8	6	2	292172

to calculate movement and stress of offshore structure we typically use $\begin{cases} \text{laboratory test} \\ \text{numerical simulator} \end{cases}$

Every structure has a natural frequency → at which it exhibits maximum movement !



most frequent Tp of the area should be far away from the natural period of structure

PROBLEM 3: Routing configuration of subsea wells in the troll field.

The Troll field has 5 subsea wells (grouped in two templates, 3 wells in Template A and 2 wells in Template B) that have the possibility to flow to separator 1 or separator 2 on the platform.

Make a sketch of the system considering the following:

- There are only two flowlines to the platform from both templates. The x-over valve for pigging is located in template B.
- There are 4 flowlines to the platform (2 from each template). Both templates have x-over valves for pigging.

Include routing valves and specify what is located on the template, and what is located topside.

Separator 1 and 2 have maximum capacities of water handling and gas handling (provided in the excel file attached). The current routing of wells is bottlenecking the separators thus requiring that production of some wells is choked.

Your task is to determine all possible routing combinations for the 5 wells and compute the total gas production rate and water production rate in both separators. Propose a routing strategy that allows honoring the separator constraints and provides a similar oil production through both separators.

w1

w2 SEP 1

w3

w4 SEP 2

w5

w1	w2	w3	w4	w5
(2)	(2)	(2)	(2)	(2)
{1, 2}	{1, 2}	{1, 2}	{1, 2}	

$2^5 = 32$

q_{g_1} q_{g_2}

q_{o_1} q_{o_2}

q_{w_1} q_{w_2}

$q_{w_1}^{max} > q_{w_1}$ $q_{g_1}^{max} > q_{g_1}$

$q_{w_2}^{max} > q_{w_2}$ $q_{g_2}^{max} > q_{g_2}$

$q_{o_1} \approx q_{o_2}$