UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering - January 2022

Module Number: CE 6251 **Module Name: Coastal Engineering (C-18)**

[Three Hours]

[Answer **all questions**, each question in PART 1 carries ONE mark. Each question in PART 2 carries TWELVE marks. Use appropriate KEY WORDS and underlying PHYSICS to explain the processes. Avoid using layman's language]

PART 1

Mark the correct box with an "X"

Q1. Two major parameters affecting wave generation are:

(i) Wave length ☐

(ii) Wind speed ☐

(iii) Wave period ☐

(iv) Fetch length ☐

(Mark two answers in Q1)

Q2. Wave shoaling can be defined as;

(i) Bending of waves ☐

(ii) An increase of wave length ☐

(iii) A reduction of water depth ☐

(iv) Increase of wave height as water depth reduces ☐

Q3. Ocean wave refraction is:

(i) Scattering of waves ☐

(ii) Bending of waves due to reducing water depth ☐

(iii) Bending of waves due to different media ☐

(iv) Increase in wave height ☐

Q4. Wave diffraction is:

(i) Increase in wave length ☐

(ii) Bending of waves due to reducing water depth ☐

(iii) Lateral transfer of wave energy along the crest ☐

(iv) Increase in wave height ☐

Q5. Wave celerity is:

(i) Speed of a group of waves ☐

(ii) Orbital velocity ☐

(iii) Speed of a single wave ☐

(iv) Wave phase velocity ☐

(Mark two answers in Q5)

Q6. Wave celerity (C) is given by:

(i) $(gT^2/2\pi)\tanh(kh)$ ☐

(ii) $2\pi/L$ ☐

(iii) $2\pi/T$ ☐

(iv) L/T ☐

Q7. Wave number (k) is given by:

(i) $(gT^2/2\pi)\tanh(kh)$ ☐

(ii) $2\pi/L$ ☐

(iii) $2\pi/T$ ☐

(iv) L/T ☐

Q8. Wave angular frequency (ω) is given by:

(i) $[(gk)tanh(kh)]^{1/2}$ ☐

(ii) $2\pi/L$ ☐

(iii) $2\pi/T$ ☐

(iv) L/T ☐

(Mark two answers in Q8)

Q9. Deep water wave length (L_0) is given by:

(i) $[(gk)tanh(kh)]^{1/2}$ ☐

(ii) $L/2\pi^2$ ☐

(iii) $gT^2/2\pi$ ☐

(iv) $2\pi/gT^2$ ☐

Q10. Significant wave height is defined as:

(i) Maximum wave height ☐

(ii) Average wave height ☐

(iii) Mean wave height ☐

(iv) Average of the highest 1/3rd of wave heights ☐

Q11. What causes longshore current ?

(i) Wind speed ☐

(ii) Tide ☐

(iii) Momentum flux ☐

(iv) Radiation stress ☐

(Mark two answers in Q11)

Q12. Longshore drift is caused by:

(i) Longshore current ☐

(ii) Cross-shore current ☐

(iii) Wind induced current ☐

(iv) Tidal current ☐

PART 2

Q1. Answer the sections (a) and (b) using the Figure Q1.

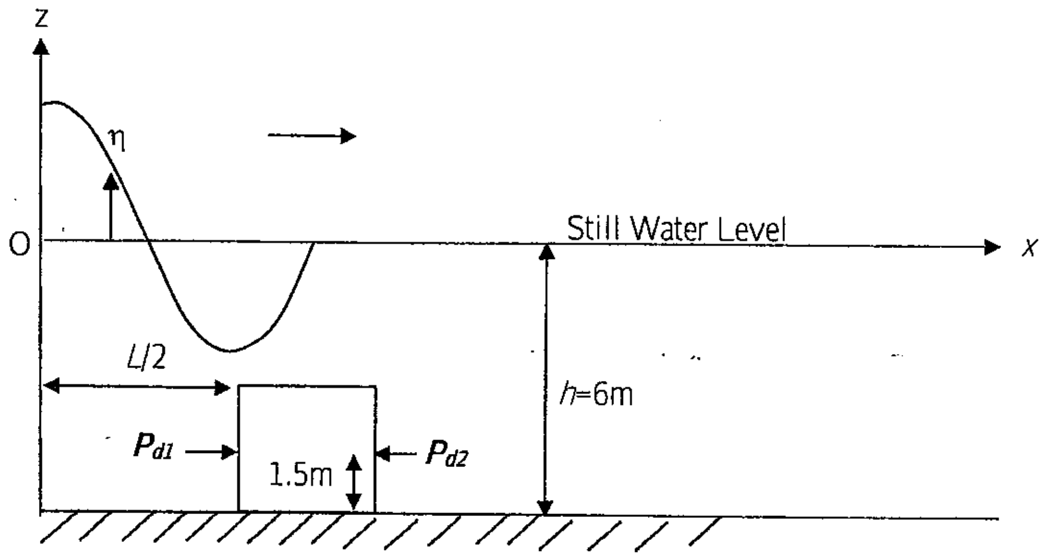

Figure Q1

(a) Linearised form of the velocity potential of a surface gravity ocean wave, written in usual notation, is given by:

$$\phi = \frac{gH}{2\omega}\frac{\cosh k(z+h)}{\cosh(kh)}\sin(kx - \omega t) \text{ ------------ Eq. 1.1}$$

At $z=\eta$ unsteady Bernoulli's equation reads as

$$\frac{P}{\rho} + \frac{1}{2}(u^2 + w^2) + gz + \frac{\partial\emptyset}{\partial t} = C(t) \text{ --------- Eq. 1.2}$$

(i) At $z=\eta$, make appropriate assumptions to obtain the linear relationship

$$\frac{P}{\rho} + gz + \frac{\partial\emptyset}{\partial t} = 0 \text{ --------- Eq. 1.3}$$

[3 marks]

(ii) The dynamic wave pressure (P_d) is equal to total pressure, P (relative to atmospheric) minus hydrostatic pressure:

$$P_d = P - \rho g(-z) \text{ --------- Eq. 1.4}$$

Obtain a relationship for dynamic wave pressure (P_d) in terms of x, z and t.

[3 marks]

(b) A cubic block of 3m x 3m x 3m dimensions, is placed at the seabed as shown in Figure Q1 at $x=L/2$ from the origin (O) where, L is wave length.

(i) Calculate dynamic wave pressure (KN/m²) at the midpoint of the cube, P_{d1} and P_{d2}, acting on the side face at time t=0. Assume wave height, H=2.0m, wave period, T=8 sec and density of sea water 1030kg/m³ (wave table is provided).

[4 marks]

(ii) Calculate the net force on the block in the x direction. Assume average pressure on the face of the block is equal to pressure at its midpoint (i.e., P_{d1} and P_{d2}).

[2 marks]

Q2. Answer the sections (a) and (b) using the Figure Q2.

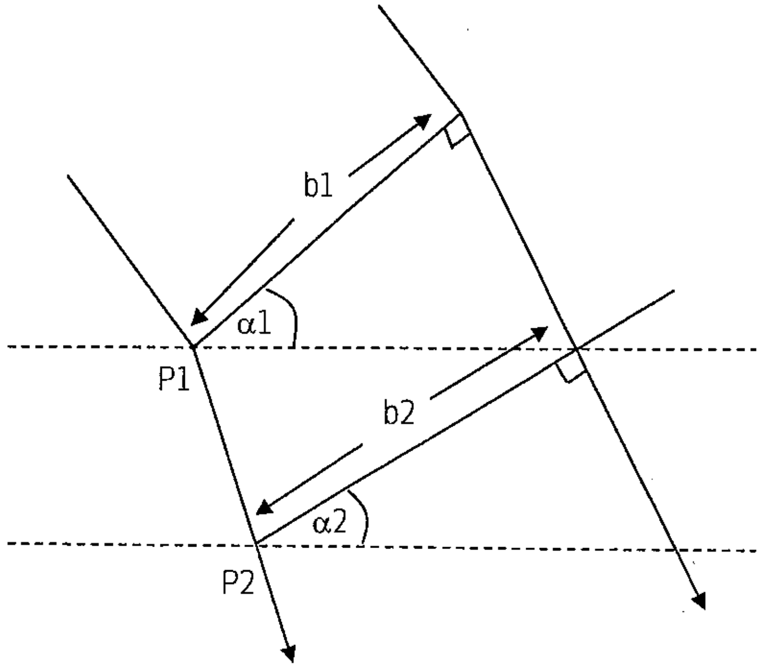

Figure Q2

(a) (i) Use physics to explain the ocean wave refraction and shoaling process making a comparison with refraction of light.

[2 marks]

(ii) Starting with the energy flux transmitted by water waves across the width b, i.e., $P=C_g E b$ where energy, $E=(1/8)\rho g H^2$ and H is the wave height, derive the relationship, $H_2/H_1=K_s.K_r$ written in usual notation taking refraction and shoaling into account. As shown in Figure Q2, H_1 is the wave height at point P1 seaward and H_2 is an unknown wave height at point P2 nearshore. Clearly state the assumptions made in the derivation.

[4 marks]

(b) Waves of 2.2m height and wave period, 10 sec in 10m water depth approach the shoreline having straight and parallel seabed contours at 30 deg angle. What is the wave height at 6m water depth? Assume wave period remains constant during wave transformation (wave table is provided in the Appendix).

Group velocity is given by; $C_g=C * n$ where C is the speed of individual waves (celerity), deep water wave celerity, $C_0=L_0/T$, T is wave period.

[6 marks]

Q3.

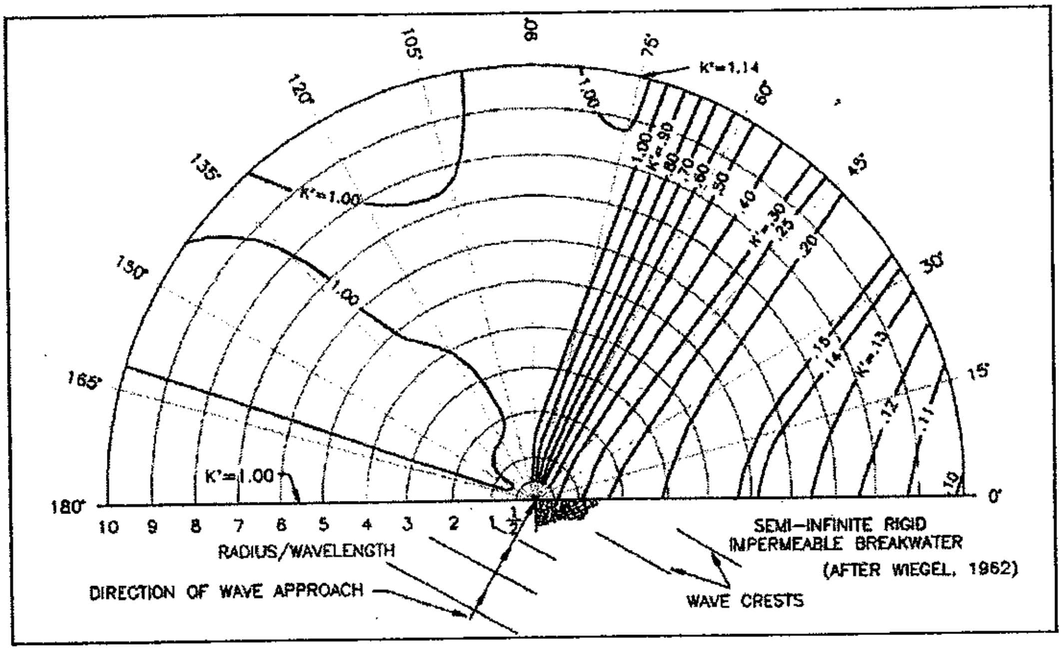

Figure Q3

(a) With the aid of sketches, if necessary, explain how diffraction of water waves occur.

[3 marks]

(b) Figure Q3 shows contours of wave diffraction coefficient K' (i.e., H_d/H_s) behind a single breakwater. Water depth, h=6m. Wave height and wave period immediately seaward of the breakwater are, H_s=2m and T=8 seconds, respectively. Wave Table is provided as Table 1 in the Appendix.

(i) Calculate local wavelength, L.

[3 marks]

(ii) Calculate the diffracted wave height, H_d at a point defined by Radius=400m from the tip of the breakwater and θ=45 degrees.

[6 marks]

Q4. (a) Hard coastal structure constructed to solve an erosion problem may shift the problem down coast (i.e., to the leeward side of the structure). Explain this statement using Figure Q4, indicting the direction of the longshore current/longshore drift, progression of accretion and erosion and evolution of shoreline position with time.

[3 marks]

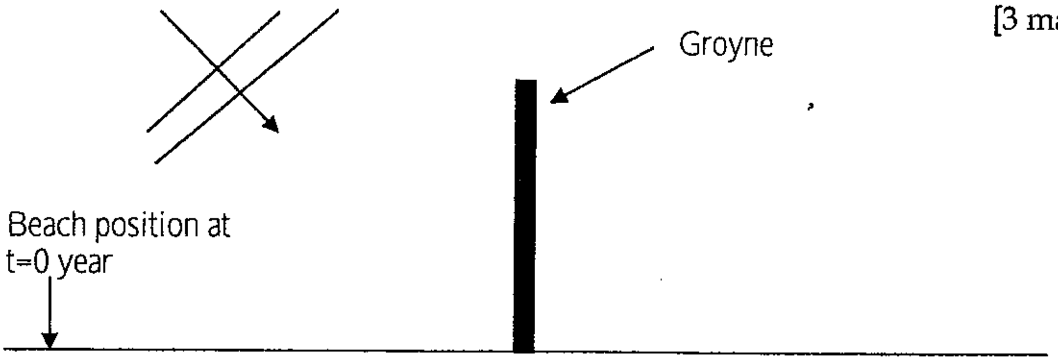

Figure Q4

(b) Physical modelling in the hydraulic laboratory is commonly conducted for the design of coastal structures. In constructing a physical model, the length and time scale ratios must be chosen to satisfy hydraulic similarity laws between the model and the prototype.

(i) Name two criteria to satisfy kinematic similarity in a physical model.

[3 marks]

(ii) If the geometric length scale ratio between a prototype and a physical model, $N_L = \frac{Lp}{Lm}$ and time scale ratio $N_T = \frac{tp}{tm}$ in usual notation, obtain a relationship for time scale ratio using the dispersion relationship:

$L = \frac{gT^2}{2\pi}\tanh(\frac{2\pi h}{L})$ --------- Eq. 4.1

where L is wavelength (m), T is wave period (seconds), h is water depth (m) and g is gravitational acceleration.

[3 marks]

(iii) A scaled down model of a monopile of 2m diameter is to be constructed in a wave flume having a width of 1m. To avoid wall effects the diameter of the model monopile should be limited to 10% of the width of the flume. Calculate the geometric length scale ratio of the model.

[3 marks]

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APPENDIX:

Table 1. Wave table

h/L0	h/L	Sinh(2πh/L)	Cosh(2πh/L)	n	C_g/C_0
0.030	0.07135	0.4634	1.1021	0.9388	0.3947
0.031	0.07260	0.4721	1.1059	0.9369	0.4000
0.032	0.07385	0.4808	1.1096	0.9349	0.4051
0.033	0.07507	0.4894	1.1133	0.9329	0.4100
0.034	0.07630	0.4980	1.1171	0.9309	0.4149
0.035	0.07748	0.5064	1.1209	0.9289	0.4196
0.036	0.07867	0.5147	1.1247	0.9270	0.4242
0.037	0.07984	0.5230	1.1285	0.9250	0.4287
0.038	0.08100	0.5312	1.1324	0.9230	0.4330
0.039	0.08215	0.5394	1.1362	0.9211	0.4372
0.040	.08329	0.5475	1.1401	0.9192	0.4414
0.041	.08442	0.5556	1.1440	0.9172	0.4455
0.042	.08553	0.5637	1.1479	0.9153	0.4495
0.043	.08664	0.5717	1.1518	0.9133	0.4534
0.044	.08774	0.5796	1.1558	0.9114	0.4571
0.045	0.0883	0.5876	1.1599	0.9095	0.4607
0.046	0.08991	0.5954	1.1639	0.9076	0.4643
0.047	0.09098	0.6033	1.1679	0.9057	0.4679
0.048	0.09205	0.6111	1.1720	0.9037	0.4713
0.049	0.09311	0.6189	1.1760	0.9018	0.4746
0.050	0.09416	0.6267	1.1802	0.8999	0.4779
0.051	0.09520	0.6344	1.1843	0.8980	0.4811
0.052	0.09623	0.6421	1.1884	0.8961	0.4842
0.053	0.09726	0.6499	1.1926	0.8943	0.4873
0.054	0.09829	0.6575	1.1968	0.8924	0.4903
0.055	0.09930	0.6652	1.2011	0.8905	0.4932
0.056	0.1003	0.6729	1.2053	0.8886	0.4960
0.057	0.1013	0.6805	1.2096	0.8867	0.4988
0.058	0.1023	0.6880	1.2138	0.8849	0.5015
0.059	0.1033	0.6956	1.2181	0.8830	0.5042
0.060	0.1043	0.7033	1.2225	0.8811	0.5068
0.061	0.1053	0.7110	1.2270	0.8792	0.5094
0.062	0.1063	0.7187	1.2315	0.8773	0.5119
0.063	0.1073	0.7256	1.2355	0.8755	0.5143
0.064	0.1082	0.7335	1.2402	0.8737	0.5167
0.065	0.1092	0.7411	1.2447	0.8719	0.5191

Wave Table (Contd.)

h/L0	h/L	Sinh(2πh/L)	Cosh(2πh/L)	n	C_g/C_0
0.066	0.1101	0.7486	1.2492	0.8700	0.5214
0.067	0.1111	0.7561	1.2537	0.8682	0.5236
0.068	0.1120	0.7633	1.2580	0.8664	0.5258
0.069	0.1130	0.7711	1.2628	0.8646	0.5279
0.070	0.1139	0.7783	1.2672	0.8627	0.5300
0.071	0.1149	0.7863	1.2721	0.8609	0.5321
0.072	0.1158	0.7937	1.2767	0.8591	0.5341
0.073	0.1168	0.8011	1.2813	0.8572	0.5360
0.074	0.1177	0.8088	1.2861	0.8554	0.5380
0.075	0.1186	0.8162	1.2908	0.8537	0.5399
0.076	0.1195	0.8237	1.2956	0.8519	0.5417
0.077	0.1205	0.8312	1.3004	0.8501	0.5435
0.078	0.1214	0.8386	1.3051	0.8483	0.5452
0.079	0.1223	0.8462	1.3100	0.8465	0.5469
0.080	0.1232	0.8538	1.3149	0.8448	0.5485
0.081	0.1241	0.8614	1.3198	0.8430	0.5501
0.082	0.1251	0.8687	1.3246	0.8413	0.5517
0.083	0.1259	0.8762	1.3295	0.8395	0.5533
0.084	0.1268	0.8837	1.3345	0.8378	0.5548
0.085	0.1277	0.8915	1.3397	0.8360	0.5563
0.086	0.1286	0.8989	1.3446	0.8342	0.5577
0.087	0.1295	0.9064	1.3497	0.8325	0.5591
0.088	0.1304	0.9141	1.3548	0.8308	0.5605
0.089	0.1313	0.9218	1.3600	0.8290	0.5619
0.095	.1366	0.9677	1.3917	0.8187	0.5693
0.096	.1375	0.9755	1.3970	0.8170	0.5704
0.097	.1384	0.9832	1.4023	0.8153	0.5716
0.098	.1392	0.9908	1.4077	0.8136	0.5727
0.099	.1401	0.9985	1.4131	0.8120	0.5737
0.1000	.1410	1.006	1.4187	0.8103	0.5747
0.1010	.1419	1.014	1.4242	0.8086	0.5757
0.1020	.1427	1.022	1.4297	0.8069	0.5766
0.1030	.1436	1.030	1.4354	0.8052	0.5776
0.1040	.1445	1.037	1.4410	0.8036	0.5785

Symbols:

h= water depth, *L*= wave length, L_0=deep water wave length = $gT^2/2\pi$