UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: February 2020

Module Number: CE 6254 **Module Name: Coastal Engineering**

[Three Hours]

[Answer **all questions**. Questions in Part 1 carry ONE mark each and questions in Part 2 carry TWELVE marks each. Part 1 must be attached to the answer sheets.]

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) Increasing 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 are the main probability distributions of a wave energy spectrum

(i) Frequency spreading ☐

(ii) Wave height distribution ☐

(iii) Directional spreading ☐

(iv) Energy distribution ☐

(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. (a) Explain why non-linear wave theories should be used in the calculation of water wave kinematics in shallow water (i.e., when $h/L<1/20$).

[3 marks]

(b) Explain using principles of physics with the aid of sketches if necessary, how:

(i) tides are generated
(ii) wave set up and set down occur
(iii) longshore currents are developed

[3 marks X 3 =9 marks]

Q2. Answer the questions (a), (b) and (c) using the Figure Q2.

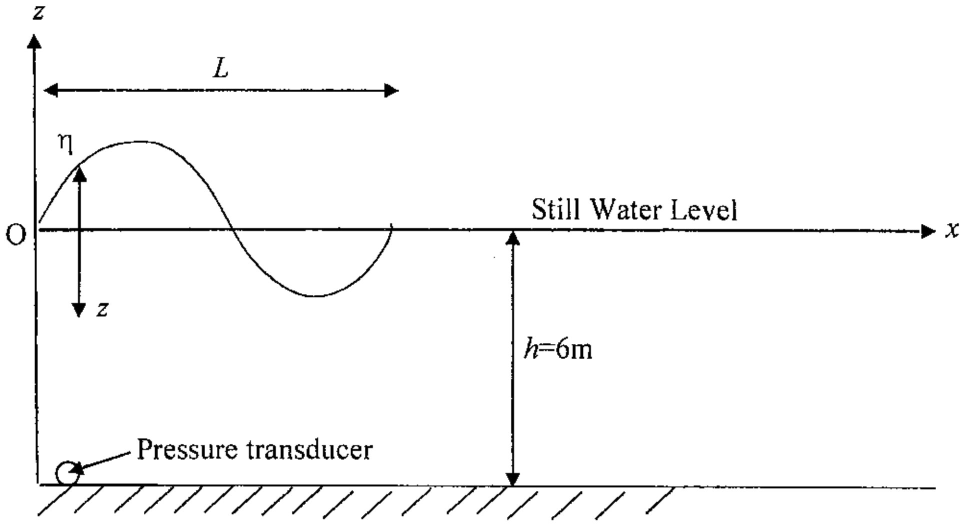

Figure Q2

(a) What are the assumptions made in deriving linear (Airy) wave theory ?

[3 marks]

(b) Unsteady Bernoulli's equation is given below for the condition, $z=\eta$

$$\frac{P}{\rho}+\frac{1}{2}(u^2+w^2)+g\eta+\frac{\partial\phi}{\partial t}=C(t) \quad \text{--------- Eq. 2.1}$$

Making appropriate assumptions obtain:

$$p(x,z,t) = -\rho\frac{\partial\phi\,(x,z,t)}{\partial t} \quad \text{---------------------Eq. 2.2}$$

when $z=\eta=0$ explaining the basis of your assumptions. p is dynamic wave pressure.

[3 marks]

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

$$\phi = \frac{gH}{2\omega}\frac{\cosh k(z+h)}{\cosh(kh)}\sin(kx - \omega t) \text{ --------- Eq. 2.3}$$

(i) Derive a relationship for dynamic wave pressure, p.

[3 marks]

(ii) A pressure transducer mounted at the sea bed showed that the peak pressure is 12.4kN/m^2 at a water depth, h=6m. If wave period T=8 sec, calculate the wave height, H at this location.

[3 marks]

Q3.

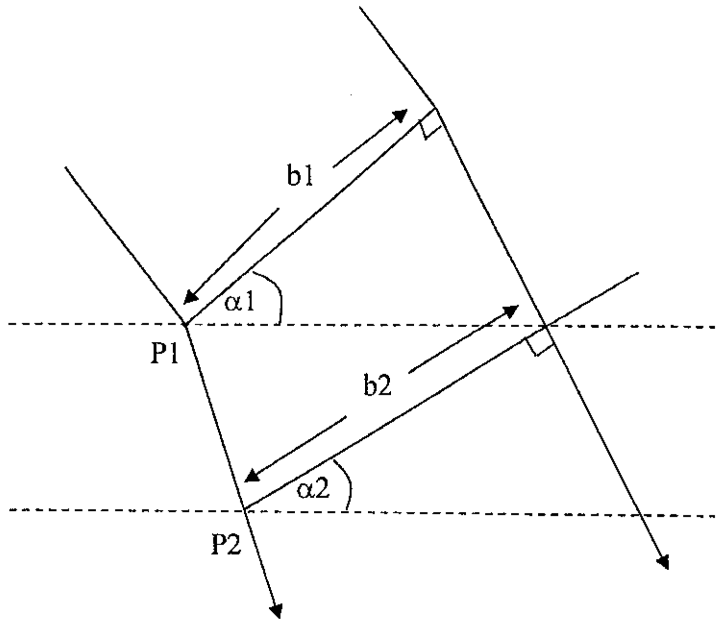

Figure Q3

(a) Explain with the aid of sketches if necessary, how and why refraction and shoaling of ocean waves occur.

[4 marks]

(b) Starting with the energy flux transmitted by water waves across the width b, i.e. $P=C_gEb$ where energy, $E=(1/8)\rho gH^2$ 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 Q3, H_1 is the wave height at point P_1 seaward and H_2 is an unknown wave height at point P_2 nearshore.

[4 marks]

(c) A wave of H=2m height and wave period, T=10 sec in h_1=8m water depth approaches the shoreline having straight and parallel sea bed contours at a α_1=30 deg angle. What is the wave height at h_2=6m water depth ?. Assume wave period, T remains constant during wave transformation (wave table is provided).

Group velocity is given by; $Cg=Cn$ where C is the speed of individual waves (celerity), $n=0.5+[kh/\sinh(2kh)]$, deep water wave celerity, $C_0=L_0/T$.

[4 marks]

Q4.

Figure Q4

(a) Name and discuss (i) hard (ii) soft coastal protection methods using sketches if necessary.

[4 marks]

(b) Figure Q4 shows the resulting shoreline after construction of two offshore breakwaters at C and B. Discuss the effect of breakwaters on the downcoast (i.e. on shoreline AB). Assume the direction of annual net longshore drift is from D to A.

[4 marks]

(c) (i) Name two criteria to satisfy hydraulic similarity of a physical model

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

$L = \frac{gT^2}{2\pi}\tanh\frac{2\pi h}{L}$

Calculate the time scale ratio (N_T) and model wave period if the wave period of the prototype is T_p=10 seconds and length scale ratio (N_L) is 15.

[4 marks]

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