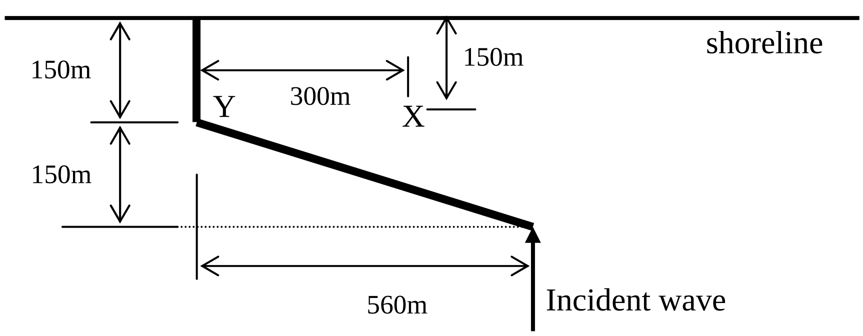
CIVL 5076 Coastal Engineering
Fall 2006
Mid Term Examination

Total Marks: 100
Time allowed: 90 minutes
Note: Attempt all questions

Question	Marks
1. Sultanate of Oman is interested in generating electricity by using wave energy on Omani Coast. The waves on the selected site approach normal to the shore with deep water wave height of 0.9 m and 6 sec period. A single unit of equipment that converts the wave power into electrical power has a length of 5m along shore and efficiency of 60 percent when installed at a water depth of 5m. How many units would be required to produce approximately 500 kW of electricity? State all the assumptions made in solving this problem.	30
2. Waves reach a shore with non-refracted deep water height of 1m and a period of 5 sec. If the beach slope is 1:8, what is the wave runup on an ideal beach with smooth impermeable surface? What is the runup if the tetra pods are placed on the beach?	20
3. For deep water condition, the particle displacements in x and y direction are given as $\xi = \frac{H}{2} e^{ky} \sin(kx - \sigma t)$ $\quad \varepsilon = \frac{H}{2} e^{ky} \cos(kx - \sigma t)$, respectively.	
(a) Show that the particles in deep water move along a circular path. The equation for a circle at origin is given as $x^2 + y^2 = R^2$, where R is the radius of the circle.	10
(b) Show that the radius of the circle in which particles move in deep water is negligibly small at a distance of $L_0 / 2$ from the surface. Assume the wave height as 1m.	10
4. Consider a breakwater as shown in the following figure. The region between the breakwater and the shoreline has a constant depth of 12m. An 8-sec, 2-m high wave is incident at the tip of the breakwater from the direction shown in the figure.	
(a) What is the wave height at point X shown in the figure?	15
(b) What is the wave height at point Y (junction of both the breakwater arms)?	15
Clearly write down all the assumptions made.	



The following formulae and graphs are provided.

$$\eta = \frac{H}{2}\cos(kx - \sigma t)\,, \quad \phi = \frac{H}{2}\frac{g\cosh k(d+y)}{\sigma\cosh kd}\sin(kx - \sigma t)$$

$$\sigma^2 = gk\tanh(kd)\,, \quad C = \sqrt{\frac{gL}{2\pi}\tanh(2\pi\frac{d}{L})} = \frac{gT}{2\pi}\tanh(2\pi\frac{d}{L})$$

$$L = \frac{gT^2}{2\pi}\tanh(kd)\,, \quad L_0 = \frac{gT^2}{2\pi}$$

$$u = \left(\frac{\pi H}{T}\right)\frac{\cosh k(d+y)}{\sinh(kd)}\cos(kx - \sigma t)\,, \qquad v = \left(\frac{\pi H}{T}\right)\frac{\sinh k(d+y)}{\sinh(kd)}\sin(kx - \sigma t)$$

$$\zeta = \left(\frac{H}{2}\right)\frac{\cosh k(d+y)}{\sinh(kd)}\sin(kx - \sigma t)\,, \qquad \varepsilon = \left(\frac{H}{2}\right)\frac{\sinh k(d+y)}{\sinh(kd)}\cos(kx - \sigma t)$$

$$p = -\rho g y + \left(\frac{\rho g H}{2}\right)\frac{\cosh k(d+y)}{\cosh(kd)}\cos(kx - \sigma t)$$

$$E = \frac{\rho g H^2 L}{8}\,, \qquad P = \frac{nE}{T}\,, \qquad n = \frac{1}{2}\left(1 + \frac{2kd}{\sinh(2kd)}\right)$$

$$\frac{H_1}{H_2} = \sqrt{\frac{n_2 L_2}{n_1 L_1}}K_R\,, \qquad \left(\frac{H}{L}\right)_{\max} = \frac{1}{7}\tanh(kd)\,, \qquad K_R = \sqrt{\frac{\cos\alpha_0}{\cos\alpha}}$$

$$\frac{\sin\alpha}{L} = \frac{\sin\alpha_0}{L_0}\,, \qquad F_D = \frac{C_D}{2}\rho_f A u|u|\,, \qquad F_L = \frac{C_L}{2}\rho_f A u|u|$$

$$F_I = C_M \rho_f \forall \frac{\partial u}{\partial t}\,, \qquad \sin\theta_p = \frac{2C_M \forall \sinh kd}{C_D A H \cosh k(d+y)}$$

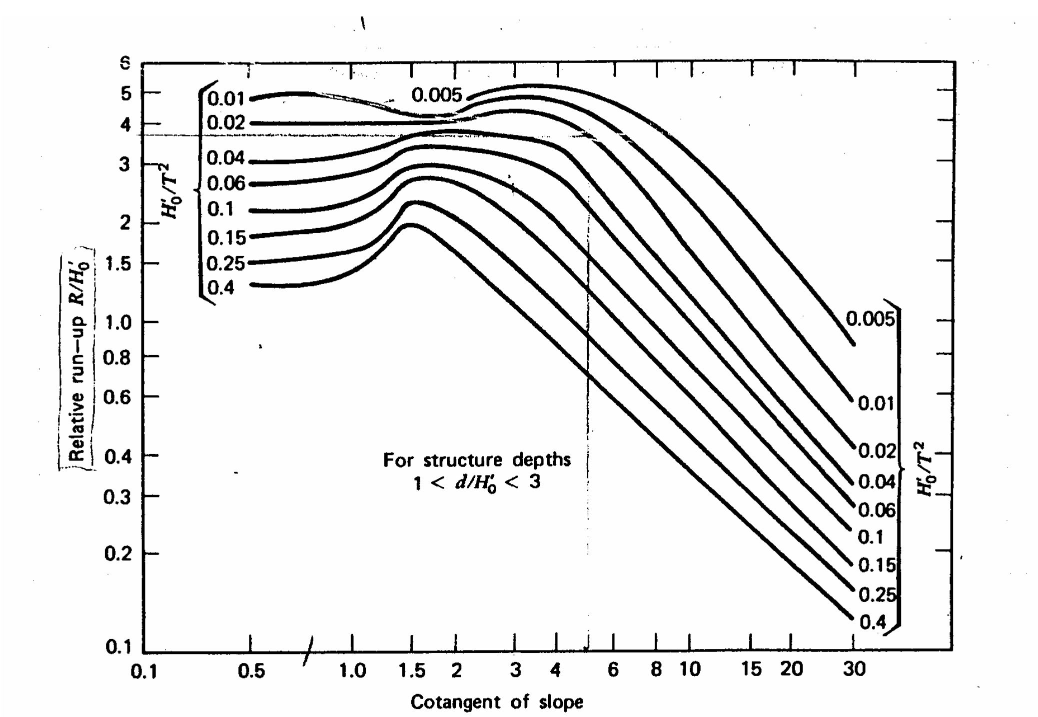


TABLE 3.1. WAVE DIFFRACTION COEFFICIENTS, K_D, AS A FUNCTION (WIEGEL, 1962) OF INCIDENT WAVE DIRECTION θ, AND POSITION, r/L AND β

	β (Degrees)												
r/L	0	15	30	45	60	75	90	105	120	135	150	165	180
							$\theta = 15°$						
1/2	0.49	0.79	0.83	0.90	0.97	1.01	1.03	1.02	1.01	0.99	0.99	1.00	1.00
1	0.38	0.73	0.83	0.95	1.04	1.04	0.99	0.98	1.01	1.01	1.00	1.00	1.00
2	0.21	0.68	0.86	1.05	1.03	0.97	1.02	0.99	1.00	1.00	1.00	1.00	1.00
5	0.13	0.63	0.99	1.04	1.03	1.02	0.99	0.99	1.00	1.01	1.00	1.00	1.00
10	0.35	0.58	1.10	1.05	0.98	0.99	1.01	1.00	1.00	1.00	1.00	1.00	1.00
							$\theta = 30°$						
1/2	0.61	0.63	0.68	0.76	0.87	0.97	1.03	1.05	1.03	1.01	0.99	0.95	1.00
1	0.50	0.53	0.63	0.78	0.95	1.06	1.05	0.98	0.98	1.01	1.01	0.97	1.00
2	0.40	0.44	0.59	0.84	1.07	1.03	0.96	1.02	0.98	1.01	0.99	0.95	1.00
5	0.27	0.32	0.55	1.00	1.04	1.04	1.02	0.99	0.99	1.00	1.01	0.97	1.00
10	0.20	0.24	0.54	1.12	1.06	0.97	0.99	1.01	1.00	1.00	1.00	0.98	1.00
							$\theta = 45°$						
1/2	0.49	0.50	0.55	0.63	0.73	0.85	0.96	1.04	1.06	1.04	1.00	0.99	1.00
1	0.38	0.40	0.47	0.59	0.76	0.95	1.07	1.06	0.98	0.97	1.01	1.01	1.00
2	0.29	0.31	0.39	0.56	0.83	1.08	1.04	0.96	1.03	0.98	1.01	1.00	1.00
5	0.18	0.20	0.29	0.54	1.01	1.04	1.05	1.03	1.00	0.99	1.01	1.00	1.00
10	0.13	0.15	0.22	0.53	1.13	1.07	0.96	0.98	1.02	0.99	1.00	1.00	1.00
							$\theta = 60°$						
1/2	0.40	0.41	0.45	0.52	0.60	0.72	0.85	1.13	1.04	1.06	1.03	1.01	1.00
1	0.31	0.32	0.36	0.44	0.57	0.75	0.96	1.08	1.06	0.98	0.98	1.01	1.00
2	0.22	0.23	0.28	0.37	0.55	0.83	1.08	1.04	0.96	1.03	0.98	1.01	1.00
5	0.14	0.15	0.18	0.28	0.53	1.01	1.04	1.05	1.03	0.99	0.99	1.00	1.00
10	0.10	0.11	0.13	0.21	0.52	1.14	1.07	0.96	0.98	1.01	1.00	1.00	1.00
							$\theta = 75°$						
1/2	0.34	0.35	0.38	0.42	0.50	0.59	0.71	0.85	0.97	1.04	1.05	1.02	1.00
1	0.25	0.26	0.29	0.34	0.43	0.56	0.75	0.95	1.02	1.06	0.98	0.98	1.00
2	0.18	0.19	0.22	0.26	0.36	0.54	0.83	1.09	1.04	0.96	1.03	0.99	1.00
5	0.12	0.12	0.13	0.17	0.27	0.52	1.01	1.04	1.05	1.03	0.99	0.99	1.00
10	0.08	0.08	0.10	0.13	0.20	0.52	1.14	1.07	0.96	0.98	1.01	1.00	1.00
							$\theta = 90°$						
1/2	0.31	0.31	0.33	0.36	0.41	0.49	0.59	0.71	0.85	0.96	1.03	1.03	1.00
1	0.22	0.23	0.24	0.28	0.33	0.42	0.56	0.75	0.96	1.07	1.05	0.99	1.00
2	0.16	0.16	0.18	0.20	0.26	0.35	0.54	0.69	1.08	1.04	0.96	1.02	1.00
5	0.10	0.10	0.11	0.13	0.16	0.27	0.53	1.01	1.04	1.05	1.02	0.99	1.00
10	0.07	0.07	0.08	0.09	0.13	0.20	0.52	1.14	1.07	0.96	0.99	1.01	1.00
							$\theta = 105°$						
1/2	0.28	0.28	0.29	0.32	0.35	0.41	0.49	0.59	0.72	0.85	0.97	1.01	1.00
1	0.20	0.20	0.24	0.23	0.27	0.33	0.42	0.56	0.75	0.95	1.06	1.04	1.00
2	0.14	0.14	0.13	0.17	0.20	0.25	0.35	0.54	0.83	1.08	1.03	0.97	1.00
5	0.09	0.09	0.10	0.11	0.13	0.17	0.27	0.52	1.02	1.04	1.04	1.02	1.00
10	0.07	0.06	0.08	0.08	0.09	0.12	0.20	0.52	1.14	1.07	0.97	0.99	1.00
							$\theta = 120°$						
1/2	0.25	0.26	0.27	0.28	0.31	0.35	0.41	0.50	0.60	0.73	0.87	0.97	1.00
1	0.18	0.19	0.19	0.21	0.23	0.27	0.33	0.43	0.57	0.76	0.95	1.04	1.00
2	0.13	0.13	0.14	0.14	0.17	0.20	0.26	0.16	0.55	0.83	1.07	1.03	1.00
5	0.08	0.08	0.08	0.09	0.11	0.13	0.16	0.27	0.53	1.01	1.04	1.03	1.00
10	0.06	0.06	0.06	0.07	0.07	0.09	0.13	0.20	0.52	1.13	1.06	0.98	1.00
							$\theta = 135°$						
1/2	0.24	0.24	0.25	0.26	0.28	0.32	0.36	0.42	0.52	0.63	0.76	0.90	1.00
1	0.18	0.17	0.18	0.19	0.21	0.23	0.28	0.34	0.44	0.59	0.78	0.95	1.00
2	0.12	0.12	0.13	0.14	0.14	0.17	0.20	0.26	0.37	0.56	0.84	1.05	1.00
5	0.08	0.07	0.08	0.08	0.09	0.11	0.13	0.17	0.28	0.54	1.00	1.04	1.00
10	0.05	0.06	0.06	0.06	0.07	0.08	0.09	0.13	0.21	0.53	1.12	1.05	1.00
							$\theta = 150°$						
1/2	0.23	0.23	0.24	0.25	0.27	0.29	0.33	0.38	0.45	0.55	0.68	0.83	1.00
1	0.16	0.17	0.17	0.18	0.19	0.22	0.24	0.29	0.36	0.47	0.63	0.83	1.00
2	0.12	0.12	0.12	0.13	0.14	0.15	0.18	0.22	0.28	0.39	0.59	0.86	1.00
5	0.07	0.07	0.08	0.08	0.08	0.10	0.11	0.13	0.18	0.29	0.55	0.99	1.00
10	0.05	0.05	0.05	0.06	0.06	0.07	0.08	0.10	0.13	0.22	0.54	1.10	1.00
							$\theta = 165°$						
1/2	0.23	0.23	0.23	0.24	0.26	0.28	0.31	0.35	0.41	0.50	0.63	0.79	1.00
1	0.16	0.16	0.17	0.17	0.19	0.20	0.23	0.26	0.32	0.40	0.53	0.73	1.00
2	0.11	0.11	0.12	0.12	0.13	0.14	0.16	0.19	0.23	0.31	0.44	0.68	1.00
5	0.07	0.07	0.07	0.07	0.08	0.09	0.10	0.12	0.15	0.20	0.32	0.63	1.00
10	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.08	0.11	0.11	0.21	0.58	1.00
							$\theta = 180°$						
1/2	0.20	0.25	0.23	0.24	0.25	0.28	0.31	0.34	0.40	0.49	0.61	0.78	1.00
1	0.10	0.17	0.16	0.18	0.18	0.23	0.22	0.25	0.31	0.38	0.50	0.70	1.00
2	0.02	0.09	0.12	0.12	0.13	0.18	0.16	0.18	0.22	0.29	0.40	0.60	1.00
5	0.02	0.06	0.07	0.07	0.07	0.08	0.10	0.12	0.14	0.18	0.27	0.46	1.00
10	0.01	0.05	0.05	0.04	0.06	0.07	0.07	0.08	0.10	0.13	0.20	0.36	1.00