

CEE 4350 Coastal Engineering

Problem Set 2

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```
from aide_design.play import*
g = pc.gravity
```

Dispersion Equation:

$$\sigma^2 = gk * \tanh(kh)$$

Problem 1

1a) Wave phase speed and wavelength:

$$\lambda = \frac{2\pi}{k}$$

$$c_p = \frac{\lambda}{T}$$

```
def wavenumber(T, h):
    """Return the wavenumber of wave using period and water height from bed."""
    k = 10 # this is a guess to find what k is
    diff = (((2*np.pi)/T)**2)-(g.magnitude * k * np.tanh(k*h))
    while diff<0:
        LHS = ((2*np.pi)/T)**2
        RHS = g.magnitude * k * np.tanh(k*h)
        diff = LHS - RHS
        k = k - 0.0001
    return k

def wavelength(T, h):
    """Return the wavelength of wave using period and water height from bed."""
    k = wavenumber(T, h)
    wavelength = 2 * np.pi / k
    return wavelength

def celerity(T,h):
    """Return the celerity of wave using period and water height from bed."""
    k = wavenumber(T,h)
    lmbda = 2 * np.pi / k
```

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    celerity = lmbda / T
    return celerity

length_tank = 190 * u.m
width_tank = 4.5 * u.m
depth = 5 * u.m
amp = 1 * u.m
period = 4 * u.s

wavenumber(period.magnitude, depth.magnitude)
wavelength(period.magnitude, depth.magnitude)
celerity(period.magnitude, depth.magnitude)

The wavenumber is 0.283, the wavelength is 22.2 meters, and the celerity is 5.55
m/s.

```

1b) Component water parcel velocities and pressure at 2 meters below the water level:

$$u = a\sigma \frac{\cosh(k(h+z))}{\sinh(kh)} \cos(kx - \sigma t)$$

$$w = a\sigma \frac{\sinh(k(h+z))}{\sinh(kh)} \sin(kx - \sigma t)$$

$$P = -\rho g z + \rho g a \frac{\cosh(k(h+z))}{\cosh(kh)} \cos(kx - \sigma t)$$

```

def u_vel(T, h, a, x, t, z):
    """Return the x-velocity of a wave."""
    sigma = (2*np.pi)/T
    k = wavenumber(T,h)
    u_vel = a * sigma * (np.cosh(k*(h+z))/np.sinh(k*h)) * np.cos(k*x - sigma*t)
    return u_vel

def w_vel(T, h, a, x, t, z):
    """Return the z-velocity of a wave."""
    sigma = (2*np.pi)/T
    k = wavenumber(T,h)
    a = amp
    w_vel = a * sigma * (np.sinh(k*(h+z))/np.sinh(k*h))* np.sin(k*x - sigma*t)
    return w_vel

def pressure(T, h, a, x, t, z):
    """Return the hydrostatic and dynamic pressure from a wave."""
    temp = 25 * u.degC
    sigma = (2*np.pi)/T

```

```

rho = pc.density_water(temp).magnitude
k = wavenumber(T, h)
pressure = (-rho * g.magnitude * z) + rho * g.magnitude * a *
np.cosh(k*(h+z))/np.cosh(k*h) * np.cos(k*x - sigma*t)
return pressure

z = -2 * u.m
x = 0 * u.m
t = 0 * u.s

u_vel(period.magnitude, depth.magnitude, amp.magnitude, x.magnitude,
t.magnitude, z.magnitude)
w_vel(period.magnitude, depth.magnitude, amp.magnitude, x.magnitude,
t.magnitude, z.magnitude)
pressure(period.magnitude, depth.magnitude, amp.magnitude, x.magnitude,
t.magnitude, z.magnitude)

```

The u-velocity is 1.12 m/s, the w-velocity is 0.0 m/s, and the pressure is 25.8 kPa.

Problem 2

Design a seawall to prevent flooding of a coastal highway. The water depth of in front of the seawall is 3 m. The design wave characteristics are period $T = 10$ seconds and amplitude $a = 0.5$ m.

2a) Minimum height of the seawall to prevent flooding:

The height of a seawall (h_s) should be determined from the amplitude of the design wave (a) and the water depth (h).

$$h_s = (2 * a) + h$$

```

a_designwave = 0.5 * u.m
h_designwave = 3 * u.m
h_s = (2 * a_designwave) + h_designwave
print(h_s)

```

The seawall should be designed to be 4 meters tall.

2b) Maximum total force on the seawall:

The maximum force on the seawall (F_m) is a function of the hydrostatic and dynamic pressure of the wave. The following equation was modified from “Water Wave Mechanics for Engineers & Scientists” by Dean and Dalrymple.

$$F_m = \rho g \frac{4h^2 + H^2}{2} + \rho g h H \frac{\tan(kh)}{kh}$$

```

def max_force(T, h, a, x, t, z):
    """Return the maximum force that a wave will induce on a seawall."""
    temp = 25 * u.degC
    sigma = (2*np.pi)/T
    rho = pc.density_water(temp).magnitude
    H = 2 * a
    k = wavenumber(T, h)
    max_force = (rho * g.magnitude) * ((4*h**2 + H**2)/2) + (rho * g.magnitude
    * h * H * np.tanh(k*h)/(k*h))
    return max_force

```

```

period_designwave = 10 * u.s
print(max_force(period_designwave.magnitude, h_designwave.magnitude,
a_designwave.magnitude, x, t, z))

```

The maximum force on the seawall is 209 N.

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pandoc Problem_Set_2.md -o Problem_Set_2.pdf
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