# 1B1-S21 Quiz B Quiz 1

NICHOLAS NHIEN

TOTAL POINTS

**33.8 / 35**

QUESTION 1

## Buoyancy 20 pts

### 1.1 pressure 2 / 2

✓ **- 0 pts Correct**

**- 0.2 pts** Numerical error

**- 0.1 pts** Used a wrong value for density of seawater or did not make use of its given value

**- 0.5 pts** Used density of steel instead of seawater

**- 0.5 pts** Ignored pressure at surface of water

### 1.2 tesnsion 6 / 6

✓ **- 0 pts Correct**

**- 1.2 pts** No units

**- 0.6 pts** Numerical error

### 1.3 out of water 2 / 2

✓ **- 0 pts Correct**

**- 0.4 pts** No units

**- 0.2 pts** Numerical error

### 1.4 bargee 5.5 / 6

**- 0 pts** Correct

**- 0.5 pts** Used incorrect ship mass or incorrect density

**- 0.5 pts** Wrong unit

**- 6 pts** Missing

**- 0.5 Point adjustment**

Incorrect reasoning (the barge itself still displaces more water after the boat has been pulled out)

### 1.5 free body 3.3 / 4

**- 0 pts** Correct

**- 0.5 pts** Mislabeled a force.

**- 2 pts** Missing free body diagram for one of the bodies

✓ **- 0.7 pts Missing a force.**

**- 1.3 pts** Missing 2 forces

**- 0.5 pts** Wrong direction on a force

Missing tension on the barge.

QUESTION 2

## wind 15 pts

### 2.1 sketch 2 / 2

✓ **- 0 pts Correct**

**- 0.5 pts** Wrong stream line separation

**- 1 pts** Did not plot stream lines

### 2.2 direction 3 / 3

✓ **- 0 pts Correct**

**- 1.5 pts** Wrong explanation

**- 0 pts** ignored main effect of wind

### 2.3 pressure 6 / 6

✓ **- 0 pts Correct**

**- 0.5 pts** calculation error

**- 0.5 pts** not absolute

**- 2 pts** Wrong approach

**- 6 pts** wrong

### 2.4 speed 4 / 4

✓ **- 0 pts Correct**

**- 1 pts** did not use pressure difference

**- 1 pts** wrong force equilibirum

**- 3 pts** incomplete

# 1B Spring 2021: Quiz 1

**Show all your work and use proper units throughout. This quiz is open-book but not open-Chegg and must be completed without help. Please write your answers into the boxes.**

## Problem 1

(20 points)

A crane lifts the 15,000 kg steel hull of a sunken ship out of the water. The density of steel is 8.05 g/cm$^3$ and the density of sea-water is 1.025 kg/l.

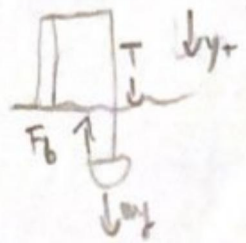
(a) Assuming the ship rests at a depth of 75 m, find the absolute pressure. [2 points]

$\rho_s = 8.05 \text{ kg/m}^3$ $\quad P_{abs} = P_{atm} + \rho g h$ $\quad = 1.025 \text{ kg/l} = 1.025 \cdot 10^3 \frac{g}{L} = 1.025 \cdot 10^3 \frac{L}{m^3}$

$= 10^5 + 1.025 \cdot 10^3 \, g (75)$

$= 8.5389 \cdot 10^5 \text{ Pa}$

(b) Calculate the static tension force in the crane's cable when the hull is fully submerged in the water (and stationary in the water column off the ground). [3 points]




$15000 \text{ kg}_{\text{ship}} = m$ $\quad \rho = \frac{m}{V}$ $\quad V_{displaced} = \frac{m}{\rho_{ship}}$ $\quad \rho_{ship} = 8.05 \text{ g/cm}^3$

$\rho_{ship} = 8.05 \cdot 10^3 \text{ kg/m}^3$

$V_{displaced} = 1.86 \text{ m}^3$

$m_w = \rho V$

$= 1.025 \cdot 10^3 \cdot 1.86 \text{ m}^3$

$= 1.9065 \cdot 10^3$

$T = m_{ship} g - F_b$

$= m_{ship} g - 1.9065 \cdot 10^3 g$

$= 1.5 \cdot 10^4 g - 1.9065 \cdot 10^3 g$

$= 1.28 \cdot 10^5 \text{ N}$

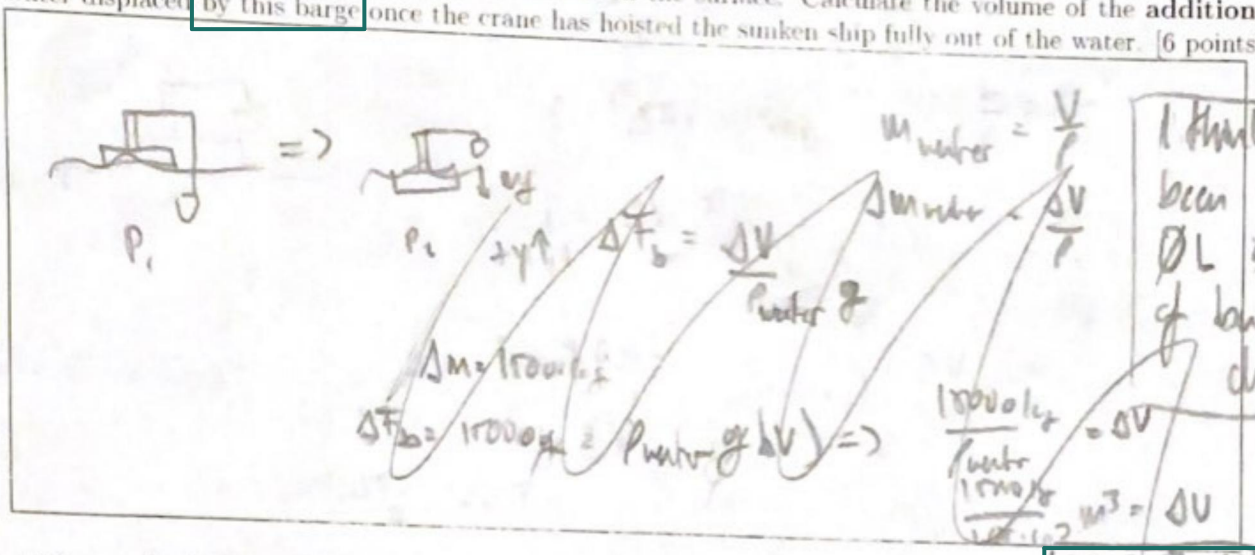
(c) Calculate the static tension in the crane's cable when the hull is completely out of the water (and stationary). [2 point]


$T = m_s g + F_{b(air)}$ $\quad F_b$ air is negligible

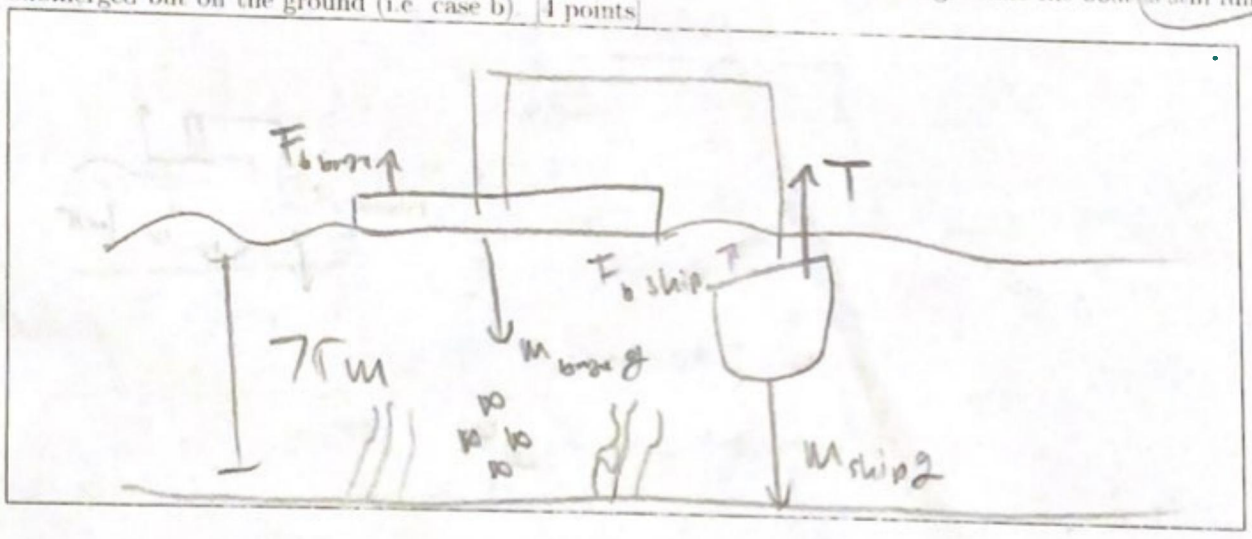
$= 1.5 \cdot 10^4 g$

$= 1.47 \cdot 10^5 \text{ N}$

(d) The crane is mounted on a barge that floats on the surface. Calculate the volume of the **additional** water displaced by this barge once the crane has hoisted the sunken ship fully out of the water. [6 points]



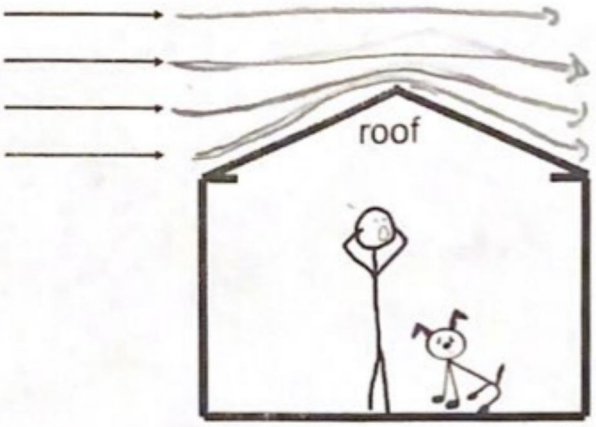

(e)Draw a free body diagram showing all forces acting on the boat and the barge while the boat is still fully submerged but off the ground (i.e. case b). [4 points]



## Problem 2

(15 points)

Strong winds blow past the roof-top of a house. The roof has an effective area of 200 $m^2$ and a total mass of 4500 kg. The roof is not bolted to the frame of the house but is merely held in place by its own gravity. Assume an air density of 1.2 g/liters.



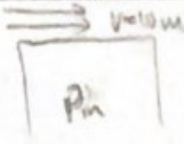

a) Qualitatively correct continue (sketch) the velocity streamlines from the incoming flow on the left, past the roof and all the way to the right. Indicate the point of lowest pressure and explain your answer. *[2 points]*

b) Is the roof pushed down, or pushed up by the strong winds? Explain! *[3 points]*

It is pushed up. There is a higher pressure inside the house than outside the house. This is due to a higher velocity of wind outside the roof causing a lower pressure than atmospheric.

From here on approximate that the roof is flat and horizontal and that the wind-speed is constant anywhere above the roof.

c) Calculate the air pressure above the roof for a wind speed of 10 m/s. Assume normal atmospheric pressure with no wind at all. *[6 points]*




$P_{in} = 1\,atm$

$P_{out} + \frac{\rho_{air} V^2}{2} = P_{atm}$

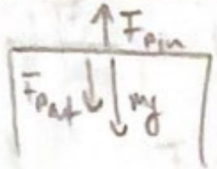
$* \quad 1.2\,g/L = 1.2\,kg/m^3$

$P_{out} = P_{atm} - \frac{1.2(10^2)}{2}$

$= 10^5 - \frac{1.2(10^2)}{2}$

$\approx 9.994 \times 10^4\ Pa$

d) At what threshold wind speed will the force on the roof be large enough so that it flies away? [4 points]




Roof flies when $F_{pin} > F_{Roof} + mg$

$\frac{F_{pin}}{A} = P_{atm}$ $\quad A P_{atm} > A\left(P_{atm} - \frac{\rho_{air} v^2}{2}\right) + mg$

$F_{pin} = P_{atm} \cdot A$ ; $\quad -mg > -\frac{\rho_{air} A v^2}{2}$

$F_{Roof} = A\left(P_{atm} - \frac{\rho_{air} v^2}{2}\right)$ $\quad \frac{2mg}{\rho_{air} A} < v^2 \Rightarrow \sqrt{\frac{2(4500)g}{1.2}} < v$

$\sqrt{1.717} < v$

$19.17 \frac{m}{s} < v$

$\sqrt{\frac{2(4500)g}{1.2 \cdot 200}} = v$

$19.17 \frac{m}{s} = v$