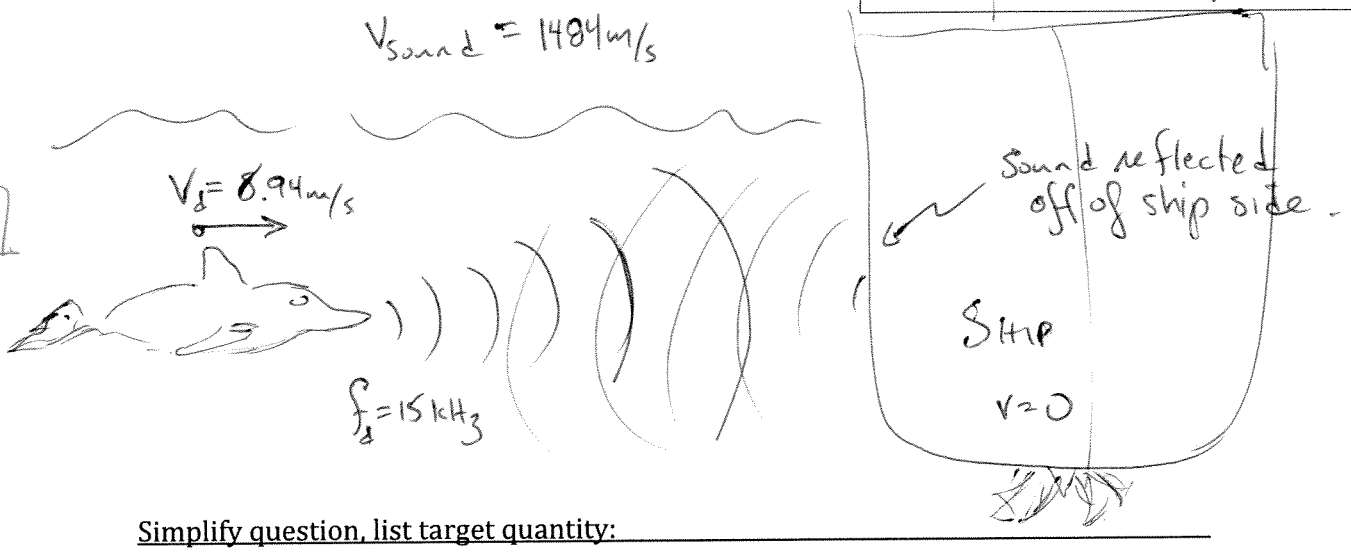
General Problem Solving Guide

Name:	EXAM 1
Lab Time:	
Date:	PROBLEM 22
Test Code:	
Problem #:	KEY

List given information, define variables, sketch picture:

In WATER

$V_{sound} = 1484 m/s$



Simplify question, list target quantity:

[1] Find frequency of returning sound wave.
Find beat frequency

List all related quantitative relationships:

[2] Doppler shift

Moving source: $f_o = \frac{V}{V - V_s} f_s$

moving observer: $f_o = \frac{V + V_o}{V} f_s$

Beat frequency

$\Delta f = f_{beat} = |f_2 - f_1|$

V = speed of sound
V_o = speed of observer
V_s = speed of source
f_s = source frequency

Outline approach, sketch diagrams if needed (or sketch next to pictures above):

[1]
1) Determine doppler-shifted frequency for sound reaching ship (moving source)
2) Ship acts as source of reflected sound
3) Determine doppler-shifted frequency for sound reaching dolphin (moving observer)
4) Difference of original and frequency from step 3 is beat freq.

Obtain a general solution:

1] Dolphin emits f_d toward stationary boat

$$f_{boat} = f_d \cdot \frac{v}{(v - v_d)}$$

2) f_{boat} is now source frequency and dolphin is moving observer

$$f = f_{boat} \cdot \frac{(v + v_d)}{v}$$

$$f = f_d \frac{v}{(v - v_d)} \cdot \frac{(v + v_d)}{v}$$

$$f = f_d \frac{(v + v_d)}{(v - v_d)}$$

$$f = 15\,kHz \frac{(1484 m/s + 8.94 m/s)}{(1484 m/s - 8.94 m/s)}$$

$$= 15.182\,kHz$$

$$f_{beat} = 15{,}182\,kHz - 15\,kHz = 182\,Hz$$

$$(0.182\,kHz)$$

Check Units:

$$Hz = Hz \frac{m/s + m/s}{m/s + m/s} = Hz$$

[1]

Check Limiting Cases:

$v_d \uparrow$	$f \uparrow$	✓
$v \uparrow$	$\Delta f \downarrow$	✓
$f_d \uparrow$	$f \uparrow$	✓
$v_d \to 0$	$f = f_d$	✓

[1]

Obtain a numeric solution:
(i.e. plug in the numbers)

$$f = 15{,}182\,Hz$$

$$\Delta f = f_{beat} = 182\,Hz$$

[1]

Why is solution reasonable? Explain.

✓ units work

✓ limiting cases work

answer seems reasonable

- $8.94 m/s = 20 mph$
- $1484 m/s = 4.3 (343 m/s)$ sound is faster in Hz

[1]