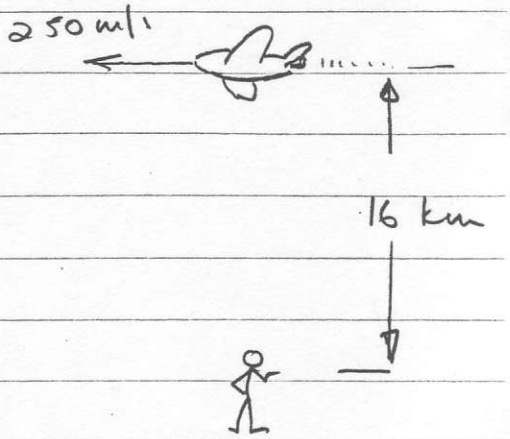
Waves - Questions - 3. A Physics

Velocity of waves

1 Radar detects objects using an echo method.

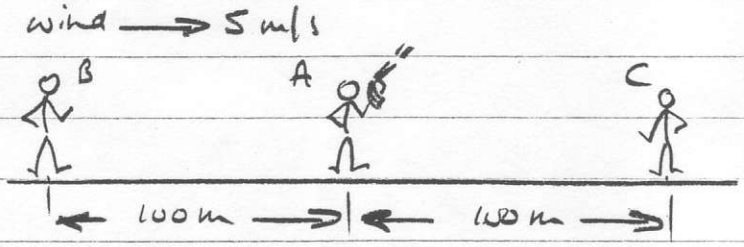


(a) Calculate the time delay between sending a pulse and receiving the echo. (3)

(b) How far does the plane move in this time? (1)

(c) Is it true that radar will always give the wrong position for a moving object? Explain your answer with a diagram. Show on your diagram where you should aim a gun to fire and hit the plane. (4) [8]

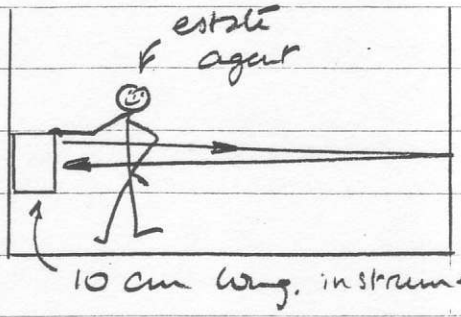
2 Three students are measuring the speed of sound, A fires the gun and B and C measure the time delay in hearing the bang.



(a) If the velocity of sound in 330 m/s relative to the air its in, what times should B and C record? (5)

(b) How does the echo method get round this problem? (1) [7]

3 Estate agents use an ultrasound echo method to measure room dimensions. If the minimum time delay the instrument can measure is 5 ms, what's the smallest room width that can be measured? (4)



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Data... V sound in air = 330 m/s

V EM waves = 3×10^8 m/s

1 ms = $1 \times 10^{-3} = \frac{1}{1000}$ sec.

Waves – 3 Answers

A Physics

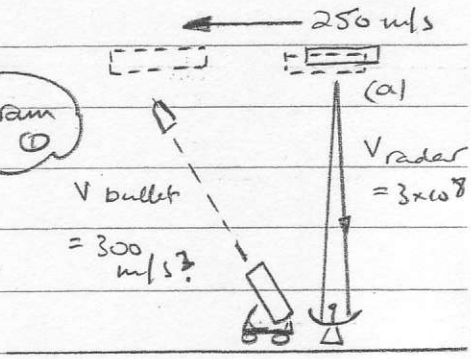
1. (a) time delay... $D = vt$ so $t_{delay} = D/v$ ① $= \frac{2 \times 16{,}000}{3 \times 10^8}$ ① ← not sound!

$= 107 \times 10^{-6}$ sec ① $= 106\ \mu s$. /1

(b) in this time plane moves...

$D_{plane} = vt$ ① $= 250 \times 107 \times 10^{-6} = 0.027$ m ① $= 27$ mm! /2

(c) Strictly, radar will always give the wrong position ①, but the error here is v. v. small ① compared to the size of the object. (see (a)). But a bullet/shell travels much slower, (v speed of the plane), so a gun would have to be aimed ahead ① of the plane



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2. (a) $D = vt$... so $t_{delay} = D/v$ ①

for B (upwind) $V_{sound} = 330 - 5 = 325$ ① m/s so $t_B = \frac{100}{325} = 0.308$ ① s

for B (downwind) $V_{sound} = 335$ ① m/s so $t_A = \frac{100}{335} = 0.299$ ① s. /

(b) In the ECHO method the sound pulse travels in both directions ①, so any effect of wind is cancelled out ① /2

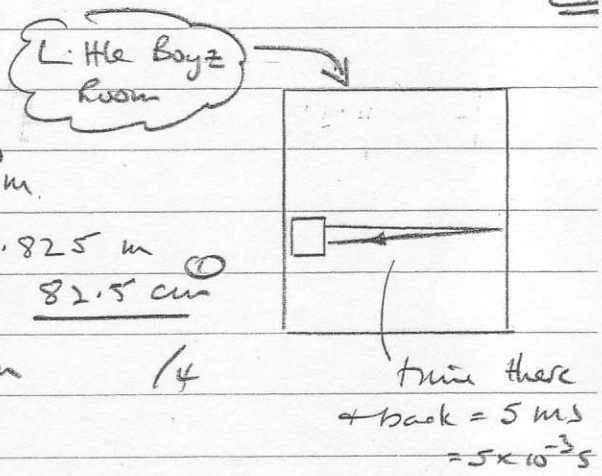
3. The Q. really is ... how far will sound travel in 5 ms?

$D = vt$ ① $= 330 \times 5 \times 10^{-3} = 1.65$ ① m.

So distance instrument to wall = 0.825 m

So max. width $= 10 + 82.5$ $= 82.5$ cm ①

$= 92.5$ ① (93) cm /4



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