Doppler - Solutions

Physics 204

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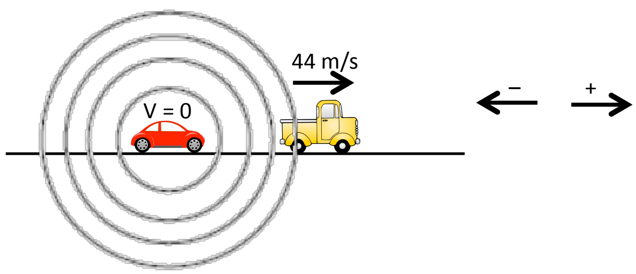
'*Case B*'

The situation is the same, but now the car is ***behind*** you when it honks its horn, instead of ahead. That is, you are moving away from it, instead of towards it.

a. Again, make a diagram showing both vehicles, vector(s) to describe their motion, and a series of successive wave-fronts.



b–g. Answer all the same questions ***b-g*** from Case A. Some things will be the same, some will not.

W = (sound) waves A = air (medium) C = car (source) T = truck (receiver)

b. Same. Source is stationary relative to air, so waves are symmetrical on all sides.

c. Car is stationary rel to air, so $V_{SA} = V_{SC}$ = 340 m/s

d. $v = \lambda f$

f in car's frame of reference = 440 hz (given)

$\mathbf{340}\ \boldsymbol{m/s} = (\mathbf{440})\boldsymbol{\lambda}$

$\boldsymbol{\lambda} = \frac{\mathbf{340}}{\mathbf{440}} \approx \mathbf{0.77}\ \boldsymbol{m}$

e. Intuitive method:

Truck is driving away from oncoming waves. Therefore speeds subtract.

V_{WT} = 340 – 44 = 296 m/s

GPR 4 method:

$\vec{V}_{WT} = \vec{V}_{WA} + \vec{V}_{AT}$

$\vec{V}_{WA} = \mathbf{340}\ \boldsymbol{m/s}$ to the right (bec. these are the waves headed towards the truck)

$\vec{V}_{AT} = -\vec{V}_{TA} = -\mathbf{44}\ \boldsymbol{m/s}$ (T is going right rel. to A, so A is going left rel. to T.)

$\vec{V}_{WT} = \mathbf{340} - \mathbf{44} = \mathbf{296}\ \boldsymbol{m/s}$

f. Length does not depend on frame of reference. Still 0.77 m.

g. $v = \lambda f$

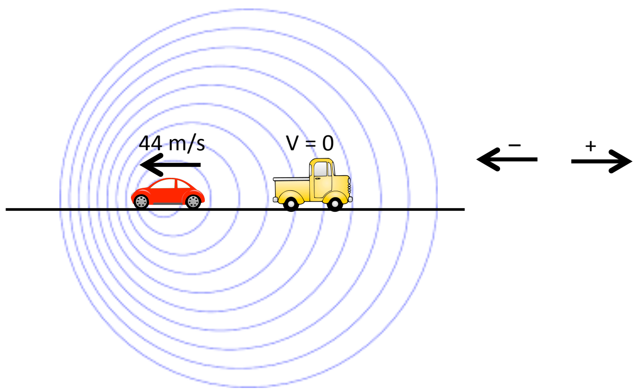
296 = (0.77)f

f = 296/0.77 = 384.4 Hz

‘*Case D*’

The situation is the same as in Case C, but now the car is moving away from you.

a. Again, make a diagram showing both vehicles, vector(s) to describe their motion, and a series of successive wave-fronts.



b–g. Answer all the same questions ***b-g*** from Case A. Some things will be the same, some will not. Again, ***c*** & ***d*** are where all the action happens.

W = (sound) waves   A = air (medium)   C = car (source)   T = truck (receiver)

b. As we can see fr the diagram waves are shorter in front. Source is moving relative to air, so waves are asymmetrical. Waves in front are squeezed, waves in back are spread out.

c. Intuitive method:

Truck is behind car, so waves ***in back*** of car are headed towards truck. These waves are moving left, the car is driving to the right, away from them—so speeds add:
440 + 44 = 384 m/s

GPR 4:

$\vec{V}_{WC} = \vec{V}_{WA} + \vec{V}_{AC}$

$\vec{V}_{WA} = \mathbf{340\ m/s}$ (to the ***right*** bec. these are the waves headed towards the truck)

$\vec{V}_{AT} = -\vec{V}_{TA} = \mathbf{44\ m/s}$ (C is going left rel. to A, so A is going right rel to C)

$\vec{V}_{WT} = \mathbf{340 + 44 = 384\ m/s}$

d. $v = \lambda f$

f in car’s frame of reference = 440 hz (given)

$\mathbf{384\ m/s} = (\mathbf{440})\lambda$

$\lambda = \frac{\mathbf{384}}{\mathbf{440}} \approx \mathbf{0.87\ m}$

e. Truck is stationary relative to the ground, so $V_{WT} = V_{WA}$ = 340 m/s

f. Length does not depend on frame of reference. Still 0.87 m.

g. $v = \lambda f$

340 = (0.87)*f*

f = 340/0.87 = 391 Hz

Analyze.

Compare your findings for Cases A & C as well as Cases B & D.

Consider your experience with the meaning and use of the term *velocity* and consider whatever you might recall of *Galileo's Principle of Relativity.*

In 1 -3 complete sentences of your own words, answer the following question:

Do your findings seem consistent or inconsistent with the way motion tends to be treated in physics?

The following is NOT a full & complete answer. It is some initial thoughts to get you thinking:

GPR says: all velocity is relative.

In Doppler we find that frequency depends on frame of reference. This is not directly connected to GPR but it is in the same spirit: turns out, frequency is like velocity; it's a relative property, dependent on reference frame.

BUT, GPR implies that "truck moving away from car" and "car moving away from truck" are not really different phenomena. After all, from the car's perspective, it's never moving; and from the truck's perspective, it's never moving. Why then do the frequencies come out differently for these two scenarios?