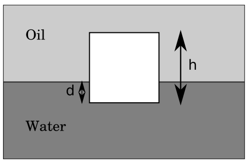
Final
Physics 5B
3/17/10

Please read the question carefully before attempting it. You will not be given any credit if you only write down the final answers. You must show your work. Please remove or cross out any work that you know to be incorrect. This will increase your score.

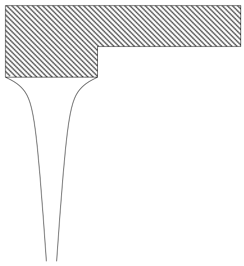
1 .
(20 points)

In the figure shown on the right, a cube of height $h = 10cm$ and made out of an unknown material floats in equilibrium at the interface between water with a density of $1000kg/m^3$ and oil of density $823kg/m^3$, at a height $d = 2cm$ below the surface of the water. Calculate the density of the the cube.



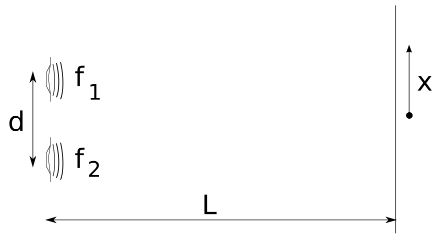
2 .
(20 points)

Water comes out of a faucet with an initial velocity of $v_0 = 1.1m/s$ distributed uniformly over the radius of the faucet with $r_0 = 0.01m$, as shown to the right. Derive an equation relating the radius of the stream as a function of the distance y below the faucet opening (the further down, the larger y.) Ignore surface tension, and take the acceleration of gravity $g = 9.8m/s^2$ and assume a uniform air pressure.



3 .
(30 points)

Two loudspeakers are separated by a distance $d = 3.5m$. Both produce equal amplitude pure tones of frequencies f_1 and f_2. You walk along a line a distance $L = 110m$ away as shown starting midway between them, at $x = 0$ and monitor the intensity of the sound. Consider the following situations:

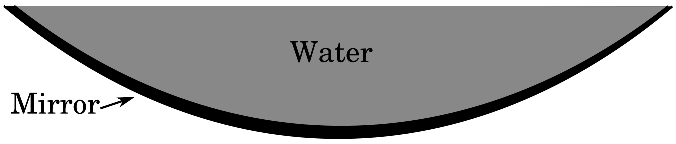


- (a) (5 points) The two loudspeakers emit sound *in phase* at the same frequency $f_1 = f_2 = 9415Hz$. Calculate the values of x where intensity has maxima near $x = 0$.
- (b) (10 points) The two loudspeakers emit sound 180 degrees *out of phase* but still at the same frequency $f_1 = f_2 = 9415Hz$. Now calculate the values of x where intensity has maxima (near $x = 0$).
- (c) (15 points) The two loudspeakers emit sound at two slightly different frequencies $f_1 = 9415$ and $f_2 = 9415.2$. At what speed do you have to walk to keep yourself at an intensity maximum (near $x = 0$)?

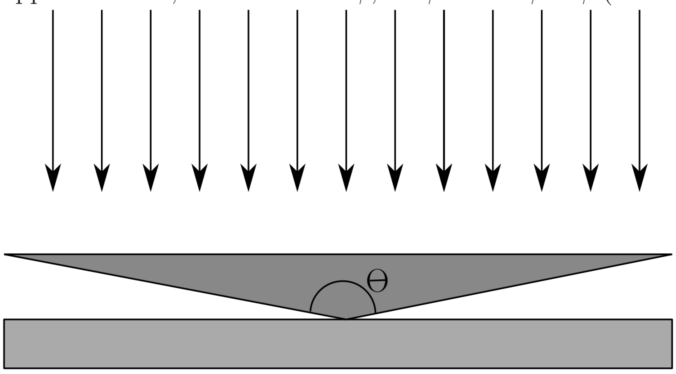
Assume L is large and also you can make use of the approximation $\sin\theta \approx \theta$. Take the velocity of sound to be $340m/s$.

4 .
(20 points)
Two loudspeakers face each other at opposite ends of a long corridor. They are connected to the same source which produces a pure tone of $f = 215 Hz$. A person walks from one speaker toward the other at a speed of $v = 2 m/s$. What "beat" frequency does the person hear? Take the velocity of sound to be $340 m/s$.

5 .
(30 points)
A horizontal concave mirror with radius of curvature of $0.97 m$ holds a layer of water with an index of refraction of 1.33 as shown. At what height above the mirror must an object be placed so that its image is at the same position as the object? You can assume that the water is shallow enough that it's thickness is very small compared to radius of curvature. The thin lens equations can then be applied.
Useful information: Lensmaker's equation: $1/f = (n-1)(1/R_1 + 1/R_2)$



6 .
(20 points)
A glass cone has a vertical angle $\theta = (180 - \delta\theta)$ degrees where $\delta\theta = 0.01$ degrees. It is pointing downwards with its apex on a flat glass plate as shown below. The refractive index of the glass is 1.5. Light of wavelength $450 nm$ is incident from very far above, and Newton's rings are seen. What is the radius of the tenth bright ring? (Consider reflection from the lower surface of the cone and the upper surface of the plate.) You can use the small angle approximation, that for small ϕ, $\sin\phi \approx \tan\phi \approx \phi$ (where ϕ is measured in radians).

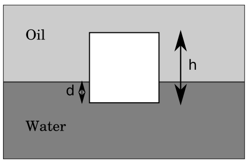


Final
Physics 5B
3/17/10

Please read the question carefully before attempting it. You will not be given any credit if you only write down the final answers. You must show your work. Please remove or cross out any work that you know to be incorrect. This will increase your score.

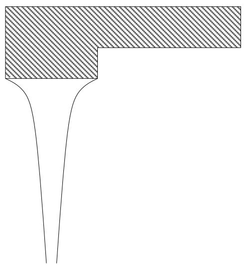
1 .
(20 points)

In the figure shown on the right, a cube of height $h = 10cm$ and made out of an unknown material floats in equilibrium at the interface between water with a density of $1000kg/m^3$ and oil of density $810kg/m^3$, at a height $d = 2cm$ below the surface of the water. Calculate the density of the the cube.



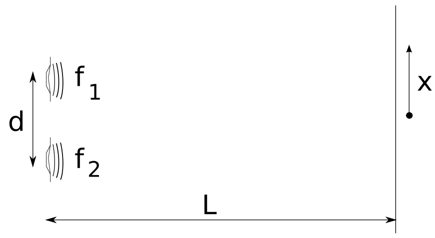
2 .
(20 points)

Water comes out of a faucet with an initial velocity of $v_0 = 0.4m/s$ distributed uniformly over the radius of the faucet with $r_0 = 0.02m$, as shown to the right. Derive an equation relating the radius of the stream as a function of the distance y below the faucet opening (the further down, the larger y.) Ignore surface tension, and take the acceleration of gravity $g = 9.8m/s^2$ and assume a uniform air pressure.



3 .
(30 points)

Two loudspeakers are separated by a distance $d = 3.25m$. Both produce equal amplitude pure tones of frequencies f_1 and f_2. You walk along a line a distance $L = 97m$ away as shown starting midway between them, at $x = 0$ and monitor the intensity of the sound. Consider the following situations:

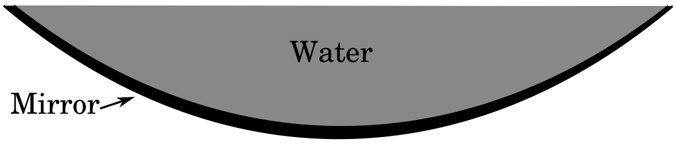


- (a) (5 points) The two loudspeakers emit sound *in phase* at the same frequency $f_1 = f_2 = 9121Hz$. Calculate the values of x where intensity has maxima near $x = 0$.
- (b) (10 points) The two loudspeakers emit sound 180 degrees *out of phase* but still at the same frequency $f_1 = f_2 = 9121Hz$. Now calculate the values of x where intensity has maxima (near $x = 0$).
- (c) (15 points) The two loudspeakers emit sound at two slightly different frequencies $f_1 = 9121$ and $f_2 = 9121.5$. At what speed do you have to walk to keep yourself at an intensity maximum (near $x = 0$)?

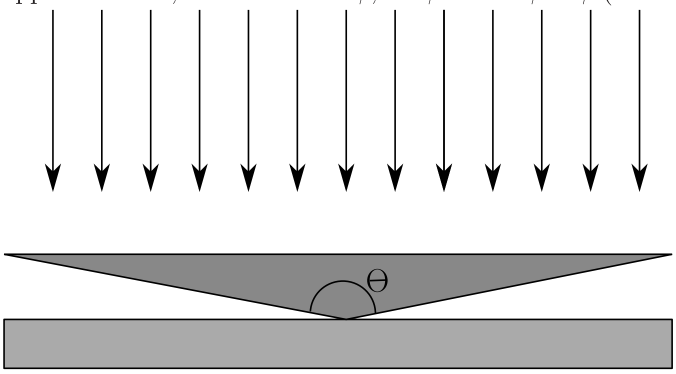
Assume L is large and also you can make use of the approximation $\sin\theta \approx \theta$. Take the velocity of sound to be $340m/s$.

4 .
(20 points)
Two loudspeakers face each other at opposite ends of a long corridor. They are connected to the same source which produces a pure tone of $f = 242Hz$. A person walks from one speaker toward the other at a speed of $v = 2.8m/s$. What "beat" frequency does the person hear? Take the velocity of sound to be $340m/s$.

5 .
(30 points)
A horizontal concave mirror with radius of curvature of $0.62m$ holds a layer of water with an index of refraction of 1.33 as shown. At what height above the mirror must an object be placed so that its image is at the same position as the object? You can assume that the water is shallow enough that it's thickness is very small compared to radius of curvature. The thin lens equations can then be applied.
Useful information: Lensmaker's equation: $1/f = (n-1)(1/R_1 + 1/R_2)$



6 .
(20 points)
A glass cone has a vertical angle $\theta = (180 - \delta\theta)$ degrees where $\delta\theta = 0.03$ degrees. It is pointing downwards with its apex on a flat glass plate as shown below. The refractive index of the glass is 1.5. Light of wavelength $457nm$ is incident from very far above, and Newton's rings are seen. What is the radius of the tenth bright ring? (Consider reflection from the lower surface of the cone and the upper surface of the plate.) You can use the small angle approximation, that for small ϕ, $\sin\phi \approx \tan\phi \approx \phi$ (where ϕ is measured in radians).



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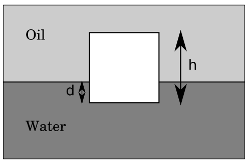
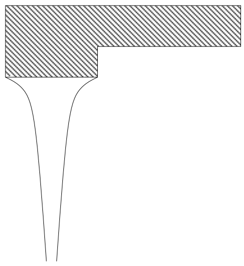
1 .
(20 points)

In the figure shown on the right, a cube of height $h = 11cm$ and made out of an unknown material floats in equilibrium at the interface between water with a density of $1000kg/m^3$ and oil of density $815kg/m^3$, at a height $d = 2cm$ below the surface of the water. Calculate the density of the the cube.



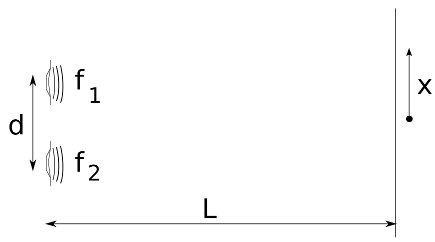
2 .
(20 points)

Water comes out of a faucet with an initial velocity of $v_0 = 0.7m/s$ distributed uniformly over the radius of the faucet with $r_0 = 0.02m$, as shown to the right. Derive an equation relating the radius of the stream as a function of the distance y below the faucet opening (the further down, the larger y.) Ignore surface tension, and take the acceleration of gravity $g = 9.8m/s^2$ and assume a uniform air pressure.



3 .
(30 points)

Two loudspeakers are separated by a distance $d = 2.5m$. Both produce equal amplitude pure tones of frequencies f_1 and f_2. You walk along a line a distance $L = 119m$ away as shown starting midway between them, at $x = 0$ and monitor the intensity of the sound. Consider the following situations:

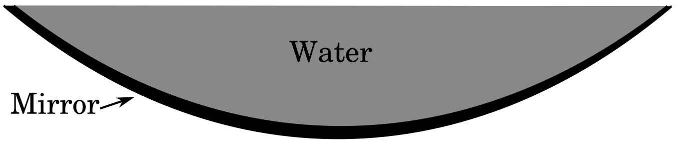


- (a) (5 points) The two loudspeakers emit sound *in phase* at the same frequency $f_1 = f_2 = 9036Hz$. Calculate the values of x where intensity has maxima near $x = 0$.
- (b) (10 points) The two loudspeakers emit sound 180 degrees *out of phase* but still at the same frequency $f_1 = f_2 = 9036Hz$. Now calculate the values of x where intensity has maxima (near $x = 0$).
- (c) (15 points) The two loudspeakers emit sound at two slightly different frequencies $f_1 = 9036$ and $f_2 = 9036.3$. At what speed do you have to walk to keep yourself at an intensity maximum (near $x = 0$)?

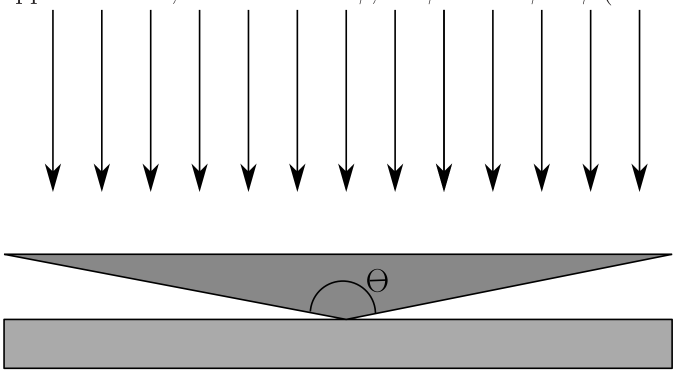
Assume L is large and also you can make use of the approximation $\sin\theta \approx \theta$. Take the velocity of sound to be $340m/s$.

4 .
(20 points)
Two loudspeakers face each other at opposite ends of a long corridor. They are connected to the same source which produces a pure tone of $f = 212Hz$. A person walks from one speaker toward the other at a speed of $v = 1.8m/s$. What "beat" frequency does the person hear? Take the velocity of sound to be $340m/s$.

5 .
(30 points)
A horizontal concave mirror with radius of curvature of $0.95m$ holds a layer of water with an index of refraction of 1.33 as shown. At what height above the mirror must an object be placed so that its image is at the same position as the object? You can assume that the water is shallow enough that it's thickness is very small compared to radius of curvature. The thin lens equations can then be applied.
Useful information: Lensmaker's equation: $1/f = (n-1)(1/R_1 + 1/R_2)$



6 .
(20 points)
A glass cone has a vertical angle $\theta = (180 - \delta\theta)$ degrees where $\delta\theta = 0.02$ degrees. It is pointing downwards with its apex on a flat glass plate as shown below. The refractive index of the glass is 1.5. Light of wavelength $453nm$ is incident from very far above, and Newton's rings are seen. What is the radius of the tenth bright ring? (Consider reflection from the lower surface of the cone and the upper surface of the plate.) You can use the small angle approximation, that for small ϕ, $\sin\phi \approx \tan\phi \approx \phi$ (where ϕ is measured in radians).



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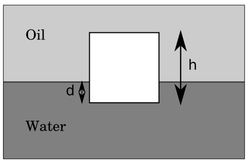
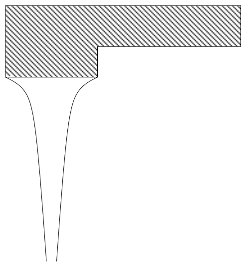
1 .
(20 points)

In the figure shown on the right, a cube of height $h = 10cm$ and made out of an unknown material floats in equilibrium at the interface between water with a density of $1000kg/m^3$ and oil of density $793kg/m^3$, at a height $d = 2cm$ below the surface of the water. Calculate the density of the the cube.



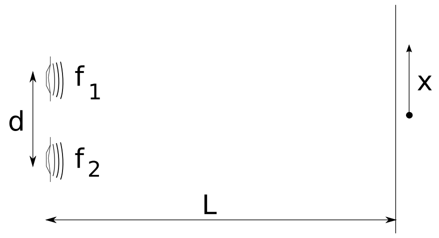
2 .
(20 points)

Water comes out of a faucet with an initial velocity of $v_0 = 0.3m/s$ distributed uniformly over the radius of the faucet with $r_0 = 0.02m$, as shown to the right. Derive an equation relating the radius of the stream as a function of the distance y below the faucet opening (the further down, the larger y.) Ignore surface tension, and take the acceleration of gravity $g = 9.8m/s^2$ and assume a uniform air pressure.



3 .
(30 points)

Two loudspeakers are separated by a distance $d = 2m$. Both produce equal amplitude pure tones of frequencies f_1 and f_2. You walk along a line a distance $L = 118m$ away as shown starting midway between them, at $x = 0$ and monitor the intensity of the sound. Consider the following situations:



- (a) (5 points) The two loudspeakers emit sound *in phase* at the same frequency $f_1 = f_2 = 9672Hz$. Calculate the values of x where intensity has maxima near $x = 0$.
- (b) (10 points) The two loudspeakers emit sound 180 degrees *out of phase* but still at the same frequency $f_1 = f_2 = 9672Hz$. Now calculate the values of x where intensity has maxima (near $x = 0$).
- (c) (15 points) The two loudspeakers emit sound at two slightly different frequencies $f_1 = 9672$ and $f_2 = 9672.1$. At what speed do you have to walk to keep yourself at an intensity maximum (near $x = 0$)?

Assume L is large and also you can make use of the approximation $\sin\theta \approx \theta$. Take the velocity of sound to be $340m/s$.

4 .

(20 points)

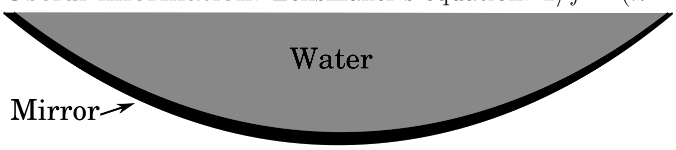
Two loudspeakers face each other at opposite ends of a long corridor. They are connected to the same source which produces a pure tone of $f = 204Hz$. A person walks from one speaker toward the other at a speed of $v = 1m/s$. What "beat" frequency does the person hear? Take the velocity of sound to be $340m/s$.

5 .

(30 points)

A horizontal concave mirror with radius of curvature of $0.71m$ holds a layer of water with an index of refraction of 1.33 as shown. At what height above the mirror must an object be placed so that its image is at the same position as the object? You can assume that the water is shallow enough that it's thickness is very small compared to radius of curvature. The thin lens equations can then be applied.

Useful information: Lensmaker's equation: $1/f = (n-1)(1/R_1 + 1/R_2)$



6 .

(20 points)

A glass cone has a vertical angle $\theta = (180 - \delta\theta)$ degrees where $\delta\theta = 0.035$ degrees. It is pointing downwards with its apex on a flat glass plate as shown below. The refractive index of the glass is 1.5. Light of wavelength $544nm$ is incident from very far above, and Newton's rings are seen. What is the radius of the tenth bright ring? (Consider reflection from the lower surface of the cone and the upper surface of the plate.) You can use the small angle approximation, that for small ϕ, $\sin\phi \approx \tan\phi \approx \phi$ (where ϕ is measured in radians).