1. This is a two dimensional motion where we treat horizontal ($\hat{x}$) and vertical ($\hat{y}$) motion separately.

$\hat{x}$: initial horizontal speed = $(100.0 \text{ m/s}) \cos (30^\circ)
= 100 \left( \frac{\sqrt{3}}{2} \right) = 50 \sqrt{3} = 86.6 \text{ m/s}.$

This is constant.

$\hat{y}$: initial vertical speed = $50.0 \text{ m/s}$.

Vertical speed at time ($t$) = $v_y(t) = 50 - [(9.80)t]$.

Height moved to hit bell = $100.0 \text{ m}$.

$= \frac{1}{2} [(50.0)(t)] - \frac{1}{2} [(9.80)t^2]
\Rightarrow t^2 - (10.2)t + (20.4) = 0$

$t = \text{either} \ 2.73 \text{ s} \ \text{(hit bell going up)}$

or

$= 7.47 \text{ s} \ \text{(hit bell going down)}$

We told class to use the "going up" time, if you used 7.47 s, but did everything OK, you should get $\frac{16}{33}$ points. See Prof. Oneill for if you did not get this credit.

In (2.73 s) the rock moves 100 m vertically and $(2.73)(2.73) = 2.36 \text{ m}$ horizontally.

Bell is $[(100)^2 + (236)^2]^{1/2} = 257 \text{ m}$ away.

At 336 m/s, sound wave takes $\frac{257}{336} = 0.7645 \text{ s}$ to reach person => total time = 3.49 s.
2. a) (i) \( \vec{F} = \nabla V = (x) \hat{x} - (y) \hat{y} + 2 \hat{z} \)

(ii) \( \nabla \times (\nabla V) = 0 \) IDENTICALLY

(iii) \( \nabla \times \vec{F} = 0 \Rightarrow \text{NO ROTATION OF } \vec{F} \) ANYWHERE

\( \nabla \cdot \vec{F} = 0 \Rightarrow \text{NO SOURCE OR SINK OF } \vec{F} \) ANYWHERE

b) (i) IF ANY VELOCITY COMPONENT IS WRONG, ANSWER IS WRONG.

\[ \vec{V}_F = \vec{V}_I + \left( \frac{a}{2w} \right) dt \]

\( x : \int_0^{\pi/4w} a x \ dt = \int_0^{\pi/4w} \tan(wt) \ dt = \left( \frac{1}{w} \right) \left[ \frac{\sin(y)}{\cos(y)} \right]_0^{\pi/4} = \left( \frac{1}{w} \right) \left[ -\frac{1}{2} \ln(2) - 0 \right] \]

\( x : \int_0^{\pi/4w} a x \ dt = \frac{1}{2w} \ln(2) = \frac{1}{40} \ln(2) \text{ (in m/s)} \)

\( y : \int_0^{\pi/4w} a y \ dt = 0 \)

\( z : \int_0^{\pi/4w} a z \ dt = \int_0^{\pi/4w} \left[ (4.9) t \right] \ dt = \left( \frac{4.9}{2} \right) \left( \frac{\pi}{4w} \right)^2 \]

\( \Rightarrow \vec{V}_F = \left[ 2 + \frac{1}{40} \ln(2) \right] \hat{x} + 4 \hat{y} - \left[ 3 - \left( \frac{\pi}{8w} \right)^2 \right] \hat{z} \)

(ii) \( V_{Fy} \text{ largest} \)
3. Ratio of masses \( \frac{m_1}{m_2} = \left( \frac{4}{3} \right) = 1.33 \)

is same as ratio of sines:

\[
\frac{\sin 53.1^\circ}{\sin 36.9^\circ} = \frac{4}{3}
\]

To three significant figures

\( y_1 \approx y_2 \approx 0.000 \) (to three significant figures)

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Points off

#1 Rock to Bell or Bell to person: 1 correct 1 wrong - 16

1 wrong

1 partly wrong - 24

Arithmetic - 3

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Points off

#2 a) (i) - (iii) All right or all points off

b) (i) - (ii) All right or all points off

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Points off

Friction = \( \mu \) or \( \mu \sin \theta \) mg - 10

Lot of arithmetic errors - 15

Two frictional forces opposing - 5

Switch Sine and Cosine - 25