

Physics Challenges for Teachers and Students

Solutions to September 2002 problems.

• Runaway Train



$$\begin{array}{cccc} x_0 = 0 & x_1 & x_2 & x_3 \\ v_0 = 0 & v_1 = aT & v_2 & v_3 \\ t_0 = 0 & t_1 & t_2 = t_1 + t & t_3 = t_1 + t' \end{array}$$

$$a = \text{constant}$$

Let L represent the length of a car. Assuming $a > 0$, $t' < t$.

$$x_2 - x_1 = L = 0.5a(t_2 - t_1)^2 + v_1(t_2 - t_1)$$

$$x_3 - x_2 = 2L = 0.5a(t_3 - t_1)^2 + v_1(t_3 - t_1)$$

$$L = 0.5at^2 + aTt \quad 2L = 0.5a(t + t')^2 + aT(t + t').$$

Therefore,

$$at^2 + 2aTt = 0.5a(t + t')^2 + aT(t + t').$$

Multiplying each term in this equation by $2/a$ gives

$$2t^2 + 4Tt = (t + t')^2 + 2T(t + t').$$

Solving this equation for T yields:

$$T = \frac{t'^2 + 2tt' - t^2}{2(t - t')}.$$

(Contributed – with art! – by
Lacresha Alexander, a student at Coosa Central
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• Rocky Landing

Minimum θ implies minimum V_{fy} and maximum V_{fx} .

In order to have the aforementioned situation, the rock has to be launched horizontally. Then:

$$V_{fy} = V_y^2 + 2gb,$$

$$(g > 0, V_y = 0)$$

$$V_{fx} = V$$

$$\tan \theta = V_{fy} / V_{fx}, \text{ so}$$

$$V_{fy} = V \tan \theta$$

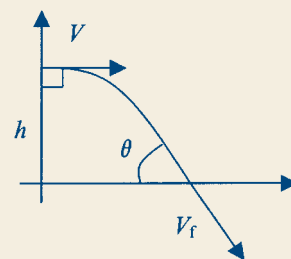
$$V_{fy}^2 = V^2 \tan^2 \theta.$$

Also:

$$V_{fy}^2 = 2gb, \text{ and}$$

$$h = (v \tan \theta)^2 / (2g).$$

(Contributed by Jae Ha Woo, a student at Concord Academy, Concord, MA)



• A Bug's Life

Before the bug's acceleration reverses direction, the distance traveled is:

$$x = \frac{1}{2} at^2.$$

The bug's velocity at that moment is:

$$v = at.$$

For the bug to return from this position to the initial position $x = 0$, one can write:

$$0 = x + vT - \frac{1}{2}aT^2.$$

Substituting x and v :

$$0 = \frac{1}{2}at^2 + atT - \frac{1}{2}aT^2.$$

Solving for T gives:

$$T = t(1 + \sqrt{2}).$$

*(Contributed by Dylan Consla, a student at
Maine School of Science and Mathematics
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• *Several other readers* also sent us correct September solutions. We would like to recognize the following contributors:

–*John F. Goehl Jr.* (Barry University, Miami Shores, FL)

–*Boyko Kakaradov*, student, Main School of Science and Mathematics (Camden, ME)

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We appreciate your contributions and hope to receive more solutions in the future.

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