1) Liz rushes down onto a subway platform only to find that her train is already departing. She witnesses each car of the train go bye. The first car goes bye in 1.50 s, the second in 1.10 s. Each car is 8.75 m long. Find the acceleration of the train.

Average v over first car

$\frac{v_1 + v_2}{2} = \frac{L}{t_1}$ $\quad$ $\frac{v_2 + v_3}{2} = \frac{L}{t_2}$ → average v over 2nd car

$\frac{L}{t_2} - \frac{L}{t_1} = \frac{v_3}{2} - \frac{v_1}{2} \Rightarrow \Delta v = 2\left(\frac{L}{t_2} - \frac{L}{t_1}\right)$

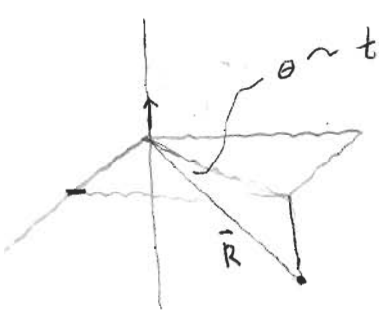
$a = \frac{\Delta v}{\Delta t} = \frac{2\left(\frac{L}{t_2} - \frac{L}{t_1}\right)}{t_2 + t_1} = \boxed{1.6\ m/s^2}$

2) A vector is given by $\mathbf{R} = 2\mathbf{i} + 3\mathbf{j} - \mathbf{k}$

a) What is the length of this vector?

$\sqrt{4 + 9 + 1} = \sqrt{14} = 3.74$

B) What angle does this vector make with the z axis?



$\theta \sim \tan\theta = \frac{1}{\sqrt{4+9}} = \frac{1}{\sqrt{13}} \Rightarrow \theta = 15.5°$

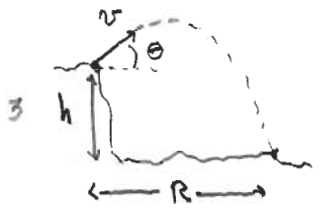
Angle $\vec{c}$ z axis is $90 - \theta = \boxed{74.5°}$

$a_z = -\hat{k} \cdot \vec{R} = |k||R|\cos\theta$

$= 1\sqrt{14}\cos\theta$

$(0,0,1)(2,3,-1) = +1 = \sqrt{14}\cos\theta$ $\quad$ $\cos\theta = \frac{+1}{\sqrt{14}} \Rightarrow \theta = \boxed{74.5°}$

3) A frog jumps from an embankment into the pond below. The embankment is 3.0 m above the pond. The frog jumps at an angle of 30 degrees with respect to the horizontal and hits the water at a distance of 2.0 m away. What was the frog's jump velocity?



$$0 = h + v_0 \sin\theta\, t - \tfrac{1}{2} g t^2$$

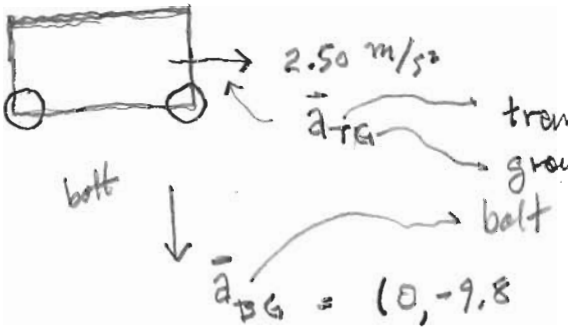
$$R = v_0 \cos\theta\, t \;\Rightarrow\; t = \frac{R}{v_0 \cos\theta}$$

$$0 = h + v_0 \sin\theta \frac{R}{v_0 \cos\theta} - \tfrac{1}{2} g \frac{R^2}{v_0^2 \cos^2\theta}$$ Solve for v_0

$$0 = 3 + (\tan 30)2 - \frac{4.9 \cdot 4}{v_0^2\ 3/4}$$

$$3 + 2\tan 30 = \frac{(4.9)(16)}{3 v_0^2} \Rightarrow v_0^2 = \frac{(4.9)(16)}{3(3 + 2\tan 30)} \Rightarrow v_0 = \boxed{2.51\ m/s}$$

4) A screw bolt drops from the ceiling of a train that is accelerating at a rate of 2.50 m/s^2. What is the acceleration of the bolt relative to the train. Give the answer in terms of the magnitude of this acceleration and the direction with respect to the train.

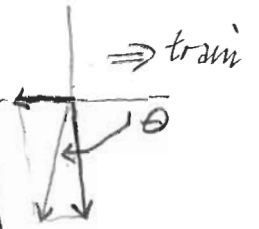


$\vec{a}_{TG}$ = train relative to ground $= (2.5, 0)$

$\vec{a}_{BG}$ = bolt $= (0, -9.8)$

$$\vec{a}_{BT} = \vec{a}_{BG} + \vec{a}_{GT}$$

$$= (0, -9.8) + (-2.5, 0) = (-2.5, -9.8)$$

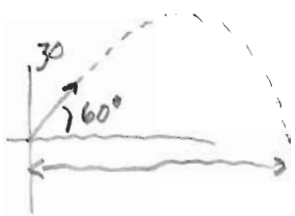


$$\tan\theta = \frac{2.5}{9.8} \Rightarrow \boxed{\theta = 14.3^\circ}$$

$$|a| = \left[(2.5)^2 + (9.8)^2\right]^{1/2}$$

$$\boxed{10.1\ m/s^2}$$

5) You throw a baseball up into the air at an angle of 60 degrees at a velocity of 30 m/s. To catch your our thrown, with what average acceleration must you proceed in the direction of your throw?



$0 = v_0 \sin\theta t - \frac{1}{2} g t^2$

$\Rightarrow v_0 \sin\theta = \frac{1}{2} g t$

this is the time you have before the ball hits the ground

$t = \frac{2 v_0 \sin\theta}{g}$ → 5.3s

$v_0 \cos\theta \, t =$

$R = \frac{2 v_0^2 \sin\theta \cos\theta}{g}$ is the distance you have to travel in time t

79.5m

$R = \frac{1}{2} a t^2$

$\frac{2R}{t^2} = a = \frac{4 v_0^2 \sin\theta \cos\theta \, g^2}{g \, 4 v_0^2 \sin^2\theta} = \frac{g}{\tan\theta} = \frac{9.8}{\tan 60} = 5.66 \, m/s^2$

6) An entirely optional question worth only extra points ....

What is Gödel's theorem??

Actually, there's more than one, but I'm thinking of the famous incompleteness theorem..

Any axiomatic system of mathematics that's strong enough to do number theory must be incomplete -- there will always be mathematical "truth" that can not be reached by the axioms.. or the system can be proven to be inconsistent!