Fall 2018

Name

Nine-digit Tech ID

Fall 2018

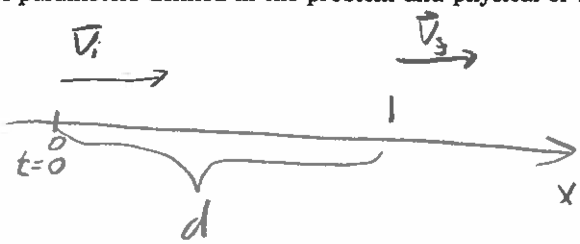
Physics 2211 AB

Quiz #

1D

- Put *nothing* other than your name and nine-digit Tech ID in the space above.
- Free-response problems are numbered I–III. Show all your work clearly, including all steps and logic. Box your answer.
- Multiple-choice questions are numbered 1–6. For each, select the answer most nearly correct, and fill the bubble for this answer on your quiz.
- You may use a calculator that cannot store letters, but no other aids or electronic devices.
- Your score will be posted when your quiz has been graded. Quiz grades become final when the next is given.

I. (20 points) A driver is traveling at speed v_i toward an intersection. The light turns red when he is a distance d away. The driver brakes with constant acceleration, but cannot stop soon enough, and reaches the intersection traveling at speed v_f. How much time did he spend braking? Express your answer in terms of parameters defined in the problem and physical or mathematical constants.



constant a

Kinematic equation

$$S(t) = V_i \cdot t + \frac{1}{2} a t^2$$

$$\Rightarrow d = V_i t + \frac{1}{2} a t^2 \quad \text{use} \quad a = \frac{V_f - V_i}{t}$$

$$\Rightarrow d = V_i t + \frac{1}{2}(V_f - V_i) t$$

$$\Rightarrow t = \frac{2d}{V_f + V_i}$$

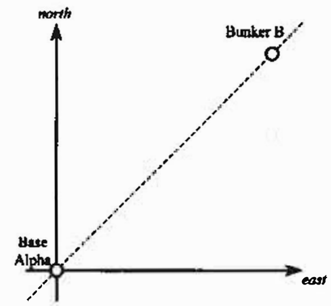
In case you thought the problem asked for the time to come to a complete stop:

$$2 \cdot a \cdot d = V_f^2 - V_i^2 \rightarrow a = \frac{V_f^2 - V_i^2}{2d}$$

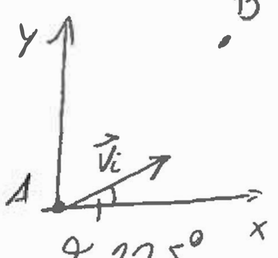
$$\text{use} \quad a = \frac{\Delta v}{\Delta t} = \frac{-V_i}{t_{total}} \rightarrow t_{total} = \frac{-V_i}{a} = \frac{-V_i}{V_f^2 - V_i^2} \cdot 2d$$

II. (20 points) You are a settler in the first permanent human colony on Mars. You set out from Base Alpha in a rover, traveling 22.5° north of east at a speed of 15.0km/hr. After 2.20 hours, a sudden rockslide destroys your rover's fuel cell, leaving you stranded. You have only 5.00 hours of oxygen remaining, and can only travel overland at a speed of 5.00 km/hr. Luckily, the colony has created a network of supply bunkers for just such an emergency. Checking your maps, you see that Bunker B is closest, located 50.0 km due northeast of Base Alpha.

How far is Bunker B from your current location? What direction should you travel, in order to proceed directly toward the bunker?

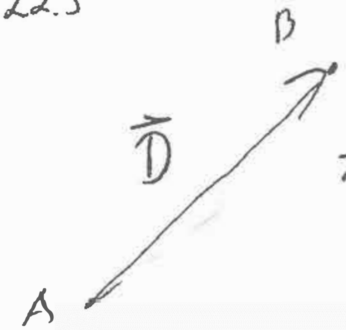


Define Coordinate system



$V_i = 15\,km/h$ $\quad \Delta t = 2.20\,hr$

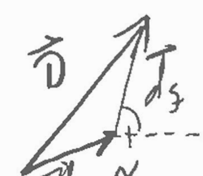
$\Rightarrow d = V_i \cdot \Delta t = 15\,km/h \cdot 2.20\,hs \approx 33\,km$ travelled by rover



$$\vec{D} = \frac{50km}{\sqrt{2}}\hat{i} + \frac{50km}{\sqrt{2}}\hat{j}$$

$\vec{d} = 33km \cdot \cos\vartheta\,\hat{i} + 33km\,\sin\vartheta\,\hat{j}$ distance vector of rover

vector from crash site to Bunker $\vec{d}_s = \vec{D} - \vec{d}$

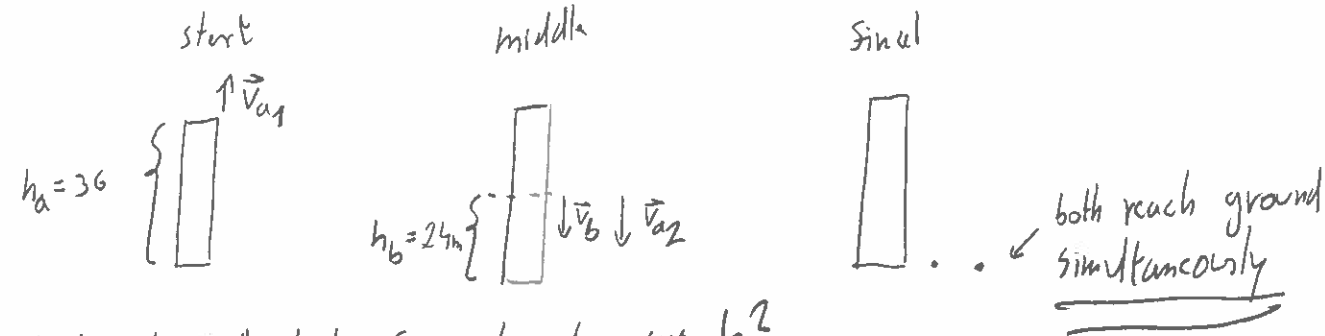


$$\vec{d}_s = \underbrace{\left(\frac{50km}{\sqrt{2}} - 33\cos\vartheta\right)}_{d_{sx}}\hat{i} + \underbrace{\left(\frac{50km}{\sqrt{2}} - 33\cdot\sin\vartheta\right)}_{d_{sy}}\hat{j}$$

distance to bunker $= \sqrt{d_{sx}^2 + d_{sy}^2} = 23.2\,km$

angle to bunker $\alpha = \tan^{-1}\frac{d_{sy}}{d_{sx}} = 12.1^\circ$ E of N

III. **(15 points) An object A is thrown upwards from the roof of a 36 m tall building with an initial speed of 7.5 m/s. On its return path the object falls all the way to the ground. A second object is thrown out of a window 24 m above the ground just at the moment when object A passes it. For what initial velocity $\vec{v}_B$ of object B do both objects arrive on the ground at the same time?**



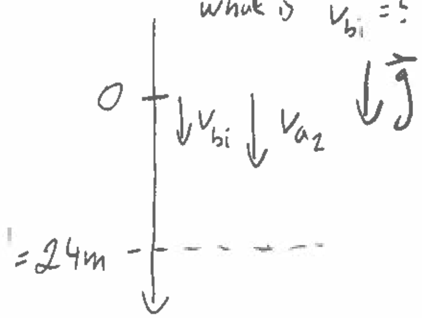
Part 1: what is the velocity of a when it passes b?

$$2 \cdot g \cdot (h_a - h_b) = V_{a_2}^2 - V_{a_1}^2$$

$$V_{a_2} = \sqrt{2g(h_a - h_b) + V_{a_1}^2}$$

Part 2. both objects are supposed to get to the ground at the same time

what is $V_{bi} = ?$ start clock when a passes by b



$$\left.\begin{aligned} x_a(t) &= V_{a_2} t + \frac{1}{2} g t^2 \\ x_b(t) &= V_{bi} t + \frac{1}{2} g t^2 \end{aligned}\right\}$$

a and b are subject to same free fall acceleration

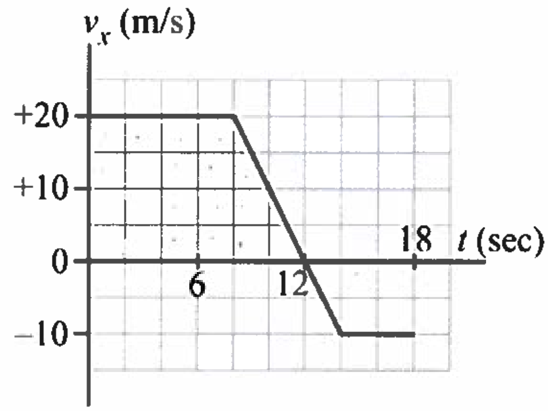
$\Rightarrow V_{bi} = V_{a_2}$ if both are supposed to hit the ground at the same time

$$\Rightarrow V_{b_i} = V_{a_i} = \sqrt{2 \cdot 9.81 \frac{m}{s^2} (36m - 24m) + \left(7.5 \frac{m}{s}\right)^2}$$

$$= \underline{\underline{17.1 \frac{m}{s}}}$$

1. (10 points) A llama runs back and forth along a straight line, with a time-dependent velocity given by the graph. At time $t = 0$, the llama is located at position $\vec{x}_i = \langle -50\,\text{m}\rangle$. What is the position of the llama at time $t = 18\,\text{s}$?

○ $\vec{x}_f = \langle +150\,\text{m}\rangle$
○ $\vec{x}_f = \langle +200\,\text{m}\rangle$
○ $\vec{x}_f = \langle +250\,\text{m}\rangle$
● $\vec{x}_f = \langle +100\,\text{m}\rangle$
○ $\vec{x}_f = \langle +50\,\text{m}\rangle$



$$\vec{X}_f = \vec{X}_i + \int_0^{18} V_x \, dt$$

count squares, each square is 10 m

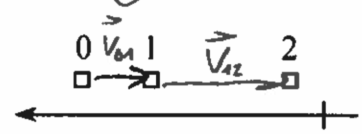
$$= -50\,\text{m} + 10\,\text{m}\,(20-5)$$

$$= -50\,\text{m} + 150\,\text{m} = 100\,\text{m}$$

2. (10 points) The right figure shows a coordinate system (origin and positive direction), along with three frames of a motion diagram for a moving object. Determine the directions of the positon, velocity, and acceleration vectors (in that order) for the object.

○ Negative, Positive, Negative
○ Positive, Positive, Positive
● Positive, Negative, Negative
○ Negative, Negative, Positive
○ Positive, Negative, Positive

$\ominus$



$$\vec{a} \propto \Delta\vec{V} = \vec{V}_{12} - \vec{V}_{01}$$

Position vector

$\vec{P}_0$

$\vec{P}_1$

$\vec{P}_2$

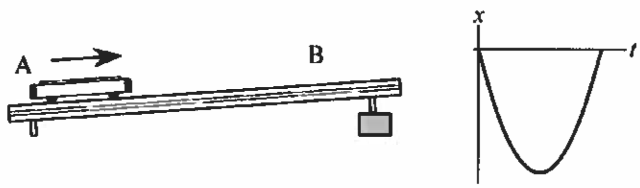
$\oplus$

$\vec{V}_{12}$

$\Delta\vec{V}$ $\vec{V}_{01}$

$\ominus$

3. (5 points) A cart is given an initial shove up an inclined ramp. The cart starts at A, coasts up the track and stops at B, and then returns back down the track to A. An observer collects position data and constructs the x-vs-t graph shown.



What coordinate system was the observer using to collect data?

○ A system with the origin at A and the positive direction pointing *toward* B.
● A system with the origin at A and the positive direction pointing *away* from B.
○ The coordinate system that was used cannot be inferred from the graph.
○ A system with the origin at B and the positive direction pointing *away* from A.
○ A system with the origin at B and the positive direction pointing *toward* A.

cart initially moves up the incline and the position is recorded as being negative → coordinate axis points down the incline
Because the initial position is 0 the origin coincides with A

4. (5 points) In the problem above, at what point (if any) during the motion does the acceleration of the cart have a *negative* value?

○ The acceleration is negative *only* as it moves from B to A.
○ The acceleration is negative while it is moving from A to B, and from B to A, but *not* at the moment that it is stopped at B.
● At no point during the cart's motion is the acceleration negative.
○ At all points during the cart's motion the acceleration is negative.
○ The acceleration is negative *only* as it moves from A to B.

the cart is subject to uniform accelerated motion
⇒ acceleration is constant
furthermore it points down the incline → positive

5. (10 points) A long-distance runner is in a straight-line race of total distance D. The runner covers the first half of the distance at a speed v_o, then becomes tired and completes the last half of the distance at a speed of $v_o/4$. What is the runner's average speed over the entire race?

- ○ $5v_o/6$
- ○ $6v_o/7$
- ● $2v_o/5$
- ○ $7v_o/8$
- ○ $2v_o/3$

$$\Delta t_1 = \frac{D/2}{V_o} \qquad \Delta t_2 = \frac{D/2}{V_o/4}$$

$$\bar{V} = \frac{D}{\Delta t_1 + \Delta t_2} = \frac{D}{\frac{D/2}{V_0}(1+4)} = \frac{2 \cdot V_0}{5}$$

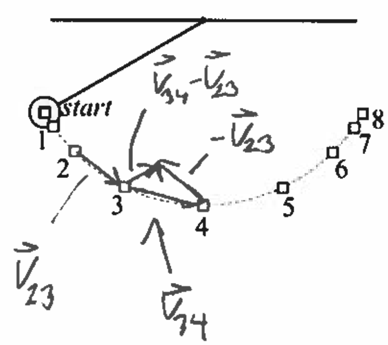
6. (5 points) The figure displays a motion diagram for a pendulum that is released at time zero. Which of the arrows below best characterizes the direction of the acceleration vector for the pendulum bob during frame #3?

● 

○ 

○ 

○ 



$$\vec{a} \propto \vec{V}_{34} - \vec{V}_{23}$$