All questions should be completed in GRFS.

1. A curling stone slides on a sheet of very smooth ice. The rock slides 12.5 m in 5.20s. Determine the average speed of the stone.
2. The distance from London to Montreal is 721km and, according to Google Maps™, it takes 8h 10min to drive there.
   a) Determine the average speed in km/h and m/s The speed limit on the 401 (and Hwy 20 in Quebec) is 100 km/h. Explain why the answer you got in a) is not 100km/h.

3. Mr. LoRusso is running through the halls at an irresponsible rate. Mr. Stranges "accidentally" trips Mr. LoRusso and Mr. LoRusso slides to a grinding ***stop*** in 1.600 seconds. If he slide for 4.300 meters determine
   a) Mr. LoRusso's initial velocity
   b) Mr. LoRuso's acceleration
4. A cop traveling at a speed of 97km/h gets passed by a speeder traveling at 145km/h. The cop immediately hits the accelerator hard and accelerates up to a speed of 160km/h. If the cop accelerates for 4.2 seconds determine the:
   a) cop's initial speed in m/s
   b) cop's final speed in m/s
   c) speeder's speed in m/s
   d) acceleration of the cop in m/s^2
   e) the distance the cop covered during the acceleration

5. Did the cop catch the speeder in question 4? If not, assuming that they both travel at constant speed of a 160km/h and 145km/h, respectively determine the time it takes for the cop to overtake the speeder. (Clue: look at the relative velocity of the two vehicles. if one car is moving at say 10m/s and the car behind it is moving at 12m/s than the second car is moving at 2 m/s relative to the first car… you know, it's like the annoying thing about cruise control… you set your cruise to like 105km/h and the person in front of you sets it to like 104km/h… you sloooowly creep up and eventually have to hit the brake… annoying.)

6. [The following questions uses collinear vectors]
   A ball is launched up at an initial velocity of 25 m/s [U]. On the way down it reaches a speed of 10m/s [D] before it gets caught in an adjacent tree.
   a) Express the initial velocity as an integer and justify.
   b) Express the final velocity as an integer and justify.
   c) What is the ball's velocity when it reaches the maximum height?
   d) If the acceleration due to gravity is $9.8 m/s^2 [D]$ find the time to reach max height
   e) Determine the max height (i.e. the displacement to the top)
   f) Determine how long it takes to reach the final velocity from max height.
   g) Determine how far the ball fell on the way down.
   h) Determine the height of the tree
   i) Compare your answer in h) to one you get by substituting directly into the equation $v_2^2 = v_1^2 + 2ad$ and solving for d. (Don't forgot to use positive and negatives to indicate the directions of your vectors.

1. A curling stone slides on a sheet of very smooth ice. The rock slides 12.5 m in 5.20s. Determine the average speed of the stone. 2.40 m/s

Given	Rtf	Formula
$d = 12.5m$ $t = 5.20s$	Average speed	$v = \frac{\Delta d}{\Delta t}$

Solution

$$v = \frac{\Delta d}{\Delta t}$$

$$v = \frac{12.5}{5.20}$$

$$v = 2.40m/s$$

$$\therefore v = 2.40m/s$$

2. The distance from London to Montreal is 721km and, according to Google Maps™, it takes 8h 10min to drive there.
   a) Determine the average speed in km/h and m/s 88.29 km/h, 24.52 m/s
   b) The speed limit on the 401 (and Hwy 20 in Quebec) is 100 km/h. Explain why the answer you got in a) is not 100km/h.

Given	Rtf	Formula
$d = 721km$ $t = 8h\ 10\min$	a) average speed in km/h and m/s b) explain why posted speed limit is not the same as average velocity	$v = \frac{\Delta d}{\Delta t}$

Solution

Convert minutes to hours

$$10\min \times \frac{1h}{60\min} = 0.167\text{h}$$

Total time $8.167h$

a) Find speed in km/h

$$v = \frac{\Delta d}{\Delta t}$$

$$v = \frac{721}{8.167}$$

$$v = 88.29km/h$$

Speed in m/s

$$v = 88.29km/h \div 3.6 = 24.52m/s$$

b)
The average velocity will be lower than the posted speed limit because of two factors. 1) congestion on the highways 2) city traffic and lower speed limits in urban areas.

3. Mr. LoRusso is running through the halls at an irresponsible rate. Mr. Stranges "accidentally" trips Mr. LoRusso and Mr. LoRusso slides to a grinding ***stop*** in 1.600 seconds. If he slide for 4.300 meters determine

a) Mr. LoRusso's initial velocity 5.375 m/s

b) Mr. LoRuso's acceleration -3.359 m/s^2

<u>Given</u>

$t = 1.600s$

$d = 4.300m$

$v_2 = 0m/s$

<u>Rtf</u>

a) v_1

b) a

<u>Formula</u>

$$d = \frac{1}{2}(v_1 + v_2)t$$

$$d = v_2 t - \frac{1}{2}at^2$$

<u>Solution</u>

a) Find v_1

$$d = \frac{1}{2}(v_1 + v_2)t$$

$$2d = (v_1 + v_2)t$$

$$\frac{2d}{t} = (v_1 + v_2)$$

$$\frac{2d}{t} - v_2 = v_1$$

$$v_1 = \frac{2d}{t} - v_2$$

$$v_1 = \frac{2(4.300)}{1.600} - 0$$

$$v_1 = 5.375m/s$$

b) find a

$$d = v_2 t - \frac{1}{2}at^2$$

$$\frac{1}{2}at^2 = v_2 t - d$$

$$at^2 = 2(v_2 t - d)$$

$$a = \frac{2(v_2 t - d)}{t^2}$$

$$a = \frac{2(0(1.600) - 4.300)}{(1.600)^2}$$

$$a = \frac{2(0 - 4.300)}{(1.600)^2}$$

$$a = -3.359m/s^2$$

$\therefore v_1 = 5.375m/s$

and

$a = -3.359m/s^2$

4. A cop traveling at a speed of 97km/h gets passed by a speeder traveling at 145km/h. The cop immediately hits the accelerator hard and accelerates up to a speed of 160km/h. If the cop accelerates for 4.2 seconds determine the:

a) cop's initial speed in m/s — 26.94 m/s
b) cop's final speed in m/s — 44.44 m/s
c) speeder's speed in m/s — 40.28 m/s
d) acceleration of the cop in m/s^2 — 4.167m/s^2
e) the distance the cop covered during the acceleration — 149.9 m

<table>
<tr><td>Given
Cop
$v_{c_1} = 97km/h$
$v_{c_2} = 160km/h$
$t_c = 4.2s$
Speeder
$v_s = 145km/h$</td><td>Rtf
a) v_{c_1} in m/s
b) v_{c_2} in m/s
c) v_s in m/s
d) a_c
e) d_c</td><td>Formula
$a = \frac{\Delta v}{\Delta t}$</td></tr>
<tr><td colspan="3">Solution</td></tr>
<tr><td>a) v_{c_1}
$v_{c_1} = 97km/h \div 3.6$
$v_{c_1} = 26.94m/s$</td><td>b) v_{c_2}
$v_{c_2} = 160km/h \div 3.6$
$v_{c_2} = 44.44m/s$</td><td>c)
$v_s = 145km/h \div 3.6$
$v_s = 40.28m/s$</td></tr>
<tr><td colspan="2">d)
$a_c = \frac{\Delta v}{\Delta t}$
$a_c = \frac{v_2 - v_1}{\Delta t}$
$a_c = \frac{44.44 - 26.94}{4.2}$
$a_c = 4.167m/s^2$</td><td>e)
$d_c = \frac{1}{2}(v_{c_1} + v_{c_2})t_c$
$d_c = \frac{1}{2}(26.94 + 44.44)(4.2)$
$d_c = 149.9m$</td></tr>
</table>

5. Did the cop catch the speeder in question 4? If not, assuming that they both travel at constant speed of a 160km/h and 145km/h, respectively determine the time it takes for the cop to overtake the speeder. (Clue: look at the relative velocity of the two vehicles. if one car is moving at say 10m/s and the car behind it is moving at 12m/s than the second car is moving at 2 m/s relative to the first car… you know, it's like the annoying thing about cruise control… you set your cruise to like 105km/h and the person in front of you sets it to like 104km/h… you slooooowly creep up and eventually have to hit the brake… annoying.) 4.63 s

Given

$v_c = 44.44m/s$

$v_s = 40.28m/s$

Rtf

t

Formula

$d = vt$

(remember d really means Δd and t really means Δt)

Solution

Step 1: Find distance speeder traveled in 4.2 seconds

$d_s = v_s t_s$

$d_s = (40.28)(4.2)$

$d_s = 169.18m$

Step 2: Find separation distance

$d_{sep} = d_s - d_c$

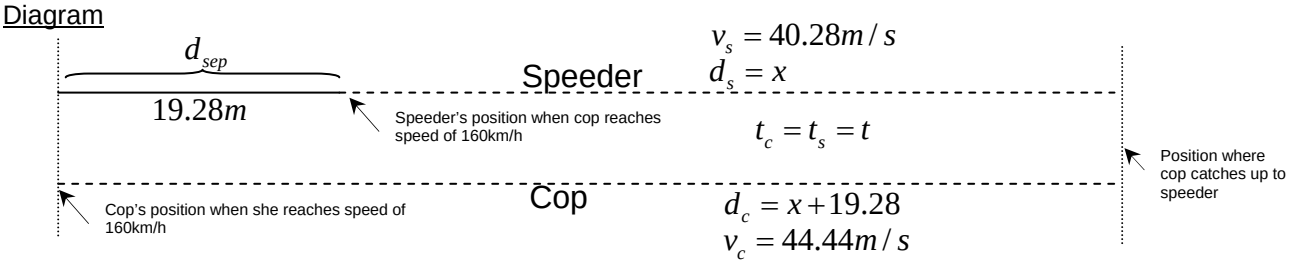
$d_{sep} = 169.18 - 149.9$

$d_{sep} = 19.28m$

Explanation

The speeder passes the cop at a speed of 145km/h. The moment the speeder passes, the cop begins to accelerate. It takes 4.2 seconds for the cop to accelerate up to 160km/h. In that time the cop covered at distance of 149.9m. The speeder, however, covered a distance of 169.18m, leaving a gap of 19.28m between the cop and the speeder. At this point both are traveling with constant speeds. If we consider this point to be the beginning, then the cop will overtake the speeder in "t" seconds. Since the speeder is traveling slower than the cop, the speeder will travel on x meters. The cop, however, will cover $x + 19.28$ meters.

Diagram



Cop

$d_c = v_c t_c$

$x + 19.28 = 44.44t$ (Eq'n ①)

Speeder

$d_s = v_s t_s$

$x = 40.28t$ (Eq'n ②)

Sub ② into ①

$(40.28t) + 19.28 = 44.44t$

$19.28 = 44.44t - 40.28t$

$19.28 = 4.16t$

$\frac{19.28}{4.16} = t$

$t = 4.63s$

Note: This is the **relative motion** part. Notice that 4.16m/s is the difference in their speeds and 19.28m is their separation distance (d=vt). This means we can treat the situation like the speeder is at rest and the cop is creeping up on him at 4.16m/s. This is known as **relative motion**.

6. [The following questions uses collinear vectors]
A ball is launched up at an initial velocity of 25 m/s [U]. On the way down it reaches a speed of 10m/s [D] before it gets caught in an adjacent tree.

a) Express the initial velocity as an integer and justify. $v_1 = +25m/s$

b) Express the final velocity as an integer and justify. $v_2 = -10m/s$

c) What is the ball's velocity when it reaches the maximum height? $v_{max} = 0m/s$

d) If the acceleration due to gravity is $9.8m/s^2[D]$ find the time to reach max height 2.55 s

e) Determine the max height (i.e. the displacement to the top) 31.89 m

f) Determine how long it takes to reach the final velocity from max height. 1.02 s

g) Determine how far the ball fell on the way down. -5.102 m or 5.102 m [D]

h) Determine the height of the tree 31.89 m + (-5.102 m)= 26.79 m

i) Compare your answer in h) to one you get by substituting directly into the equation $v_2^2 = v_1^2 + 2ad$ and solving for d. (Don't forgot to use positive and negatives to indicate the directions of your vectors. +26.79 m

Given

$\vec{v}_1 = 25m/s[U]$

$\vec{v}_2 = 10m/s[D]$

$\vec{a} = 9.8m/s^2[D]$

Rtf

Formula

$a = \frac{\Delta v}{\Delta t}$, $v_2^2 = v_1^2 + 2ad$

Solution

a) $v_1 = +25m/s$

b) $v_2 = -10m/s$

c) $v_{max} = 0m/s$

when the ball reaches max height it stops rising, therefore, the ball temporarily stops before it falls again.

d) Find time

$a = \frac{\Delta v}{\Delta t}$

$\Delta t = \frac{\Delta v}{a}$

$\Delta t = \frac{v_2 - v_1}{a}$

$\Delta t = \frac{0-(+25)}{-9.8}$

$\Delta t = 2.55s$

e) Find max height

$v_2^2 = v_1^2 + 2ad$

$v_2^2 - v_1^2 = 2ad$

$\frac{v_2^2 - v_1^2}{2a} = d$

$d = \frac{v_2^2 - v_1^2}{2a}$

$d = \frac{(0)^2 - (+25)^2}{2(-9.8)}$

$d = +31.89m$

$\vec{d} = 31.89m[U]$

f) Find time

$a = \frac{\Delta v}{\Delta t}$

$\Delta t = \frac{\Delta v}{a}$

$\Delta t = \frac{v_2 - v_1}{a}$

$\Delta t = \frac{(-10)-(0)}{-9.8}$

$\Delta t = 1.02s$

g) Find distance

$d = \frac{v_2^2 - v_1^2}{2a}$

$d = \frac{(-10)^2 - (0)^2}{2(-9.8)}$

$d = -5.102m$

$\vec{d} = 5.102m[D]$

h) Height of the tree

$\vec{h} = \vec{d}_1 + \vec{d}_2$

$h = 31.89 + (-5.102)$

$h = 26.79m$

i) Find d

$d = \frac{v_2^2 - v_1^2}{2a}$

$d = \frac{(-10)^2 - (+25)^2}{2(-9.8)}$

$d = +26.79m$

$\vec{d} = 26.79m[U]$

Therefore the height of the tree is 26.79m