Mechanics I - Question Bank – 8

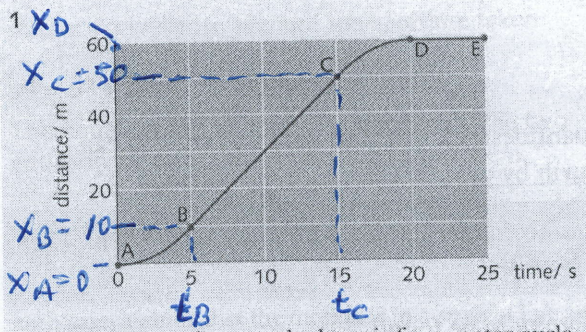
2018-2019 Fall Semester

KEY

Part A

Answer the questions below.

1



The distance–time graph above is for a motor cycle travelling along a straight road.

a) What is the motor cycle doing between points D and E on the graph?

b) Between which points is it accelerating?

c) Between which points is its speed steady?

d) What is this steady speed?

e) What is the distance travelled between A and D?

f) What is the average speed between A and D?

a) This is distance-time graph. Between point D-E, the position of the motorcycle is 40 m. It is staying there.

b) Between A-B and C-D it is accelerating.

c) Between B-C, it is speed is steady.

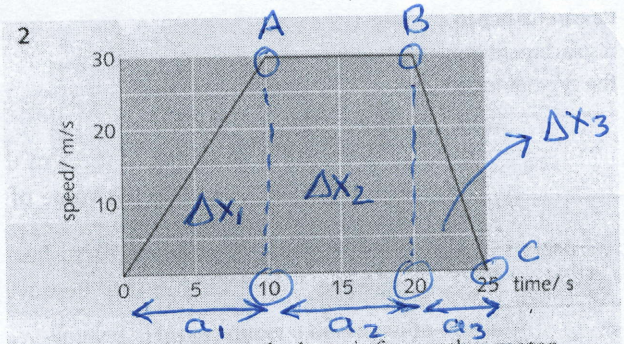
d) $v = \frac{\Delta x}{\Delta t} = \frac{x_C - x_B}{t_C - t_B} = \frac{50-10}{15-5} = \frac{40}{10} = 4\ \frac{m}{s}$

e) $x_A = 0 \quad x_D = 60m \quad \Delta x = 60-0 = 60m$

f) $t_A = 0 \quad t_D = 20s$

$v_{ave} = \frac{60-0}{20-0} = \frac{60}{20} = 3\ m/s$

2



The speed–time graph above is for another motor cycle travelling along the same road.

a) What is the motor cycle's maximum speed?

b) What is the acceleration during the first 10 s?

c) What is its deceleration during the last 5 s?

d) What distance is travelled during the first 10 s?

e) What is the total distance travelled?

f) What is the time taken for the whole journey?

g) What is the average speed for the whole journey?

a) The graph shows change in speed by time interval. It is max speed $30\ \frac{m}{s}$.

b) $t_0 = 0 \quad t_A = 10s \quad v_0 = 0 \quad v_A = 30\ m/s$

$a_1 = \frac{\Delta v}{\Delta t} = \frac{v_A - v_0}{t_A - t_0} = \frac{30-0}{10-0} = 3\ m/s^2$

c) $t_B = 20s \quad t_C = 25s \quad v_B = 30\ \frac{m}{s} \quad v_C = 0$

$a_3 = \frac{v_C - v_B}{t_C - t_B} = \frac{30-20}{25-20} = \frac{10}{5} = 2\ m/s^2$

d) $v = \frac{\Delta x}{\Delta t} \Rightarrow \Delta x = v_0 t + \frac{1}{2} a t^2$

$\Delta x_1 = \frac{1}{2} 3 (10)^2 = 150m$

e) $\Delta x_2 = v \cdot \Delta t = 30 \cdot \Delta t = 30 \cdot 10 = 300\ m$

$\Delta x_3 = v_B t_3 + \frac{1}{2} a t_3^2$

$\Delta x_3 = 30 \cdot 5 + \frac{1}{2}(-6)\, 5^2$

$\Delta x_3 = 150 - 75 = 75m$

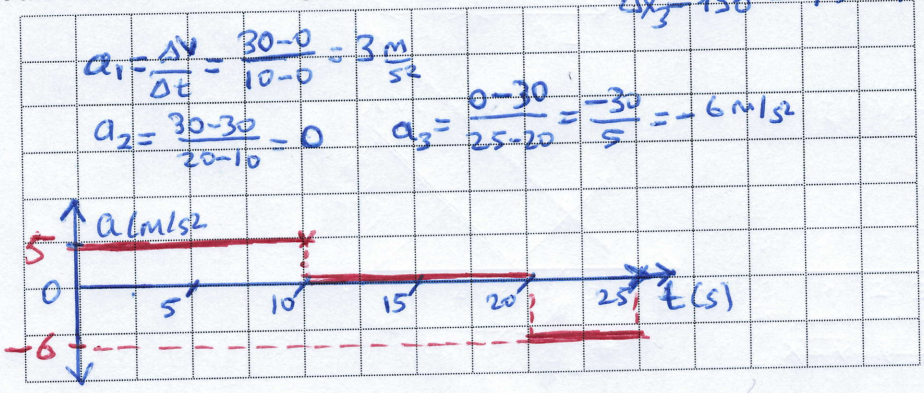
$t_3 = 25-20 = 5s$

$a_3 = \frac{v_C - v_B}{t_C - t_B}$

$a_3 = \frac{0-30}{25-20} = \frac{-30}{5}$

$a_3 = -6\ \frac{m}{s^2}$

g) Plot the acceleration – time graph of the motor cycle.



$a_1 = \frac{\Delta v}{\Delta t} = \frac{30-0}{10-0} = 3\ \frac{m}{s^2}$

$a_2 = \frac{30-30}{20-10} = 0$

$a_3 = \frac{0-30}{25-20} = \frac{-30}{5} = -6\ m/s^2$

g) $v_{avg} = \frac{x_{total}}{t_{total}}$

$v_{avg} = \frac{\Delta x_1 + \Delta x_2 + \Delta x_3}{25s}$

$= \frac{150+300+75}{25}$

$v_{avg} = \frac{475}{25} = 19\ \frac{m}{s}$

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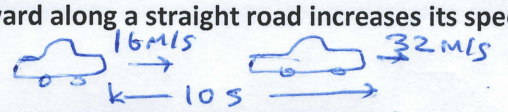
Part B

1. A car moving eastward along a straight road increases its speed uniformly from 16 m/s to 32 m/s in 10.0 s.



a. What is the car's average acceleration?

b. What is the car's average velocity?

c. How far did the car move while accelerating?

a) $a = \frac{\Delta V}{\Delta t} = \frac{32-16}{10} = \frac{16}{10} = 1.6 \frac{m}{s^2}$

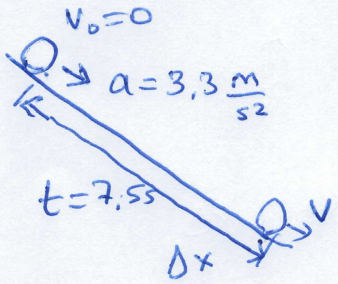
b) $V_{avg} = \frac{V_f + V_o}{2} = \frac{32+16}{2} = \frac{48}{2} = 24 \frac{m}{s}$

c) $\Delta x = V_o \cdot t + \frac{1}{2} a t^2 \quad (t = 10s)$

$\Delta x = 16 \cdot 10 + \frac{1}{2}(1.6) \cdot 10^2$

$= 160 + (0.8) \cdot 100 = 160 + 80 = 240 \, m$

2. A ball initially at rest rolls down a hill and has an acceleration of 3.3 m/s^2. If it accelerates for 7.5 s, how far will it move during this time?

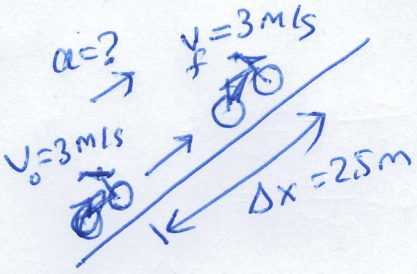


$\Delta x = V_o \cdot t + \frac{1}{2} a t^2$

$\Delta x = 0 \cdot (7.5) + \frac{1}{2}(3.3)(7.5)^2$

$\Delta x = 92.8 \, m$

3. A bicycle rider rides up a hill at a velocity of 3.0 m/s. At some point, he stops pedalling and coasts, coming to a stop. The distance from the point he stops pedalling and the point he stops is 2.5 meters. Find his acceleration during the time he is coasting.



$V_f^2 = V_o^2 + 2 a \Delta x$

$0 = 3^2 + 2 \cdot a \cdot 2.5$

$0 = 9 + 5 \cdot a \quad a = \frac{-9}{5} = -1.8 \frac{m}{s^2}$

$a = -1.8 \frac{m}{s^2}$

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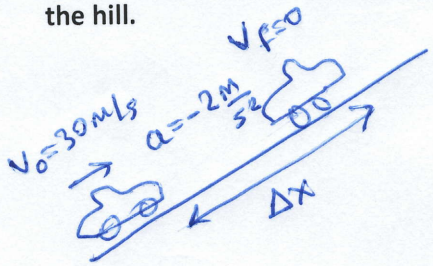
4. A car is approaching a hill at 30.0 m/s when its engine suddenly fails just at the bottom of the hill. The car moves with a constant acceleration of 2.00 m/s² while coasting up the hill. (a) Write equations for the position along the slope and for the velocity as functions of time, taking $x = 0$ at the bottom of the hill, where $v_i = 30.0$ m/s. (b) Determine the maximum distance the car rolls up the hill.



a) $\Delta x = x_f - x_0 = v_0 t + \frac{1}{2} a t^2$

$x_f = \cancel{x_0}^{0} + v_0 t + \frac{1}{2} a t^2$

$\boxed{x_f = v_0 t + \frac{1}{2} a t^2}$

b) $\cancel{v_f}^{0} = v_0 + at = 30 + (-2) \cdot t$

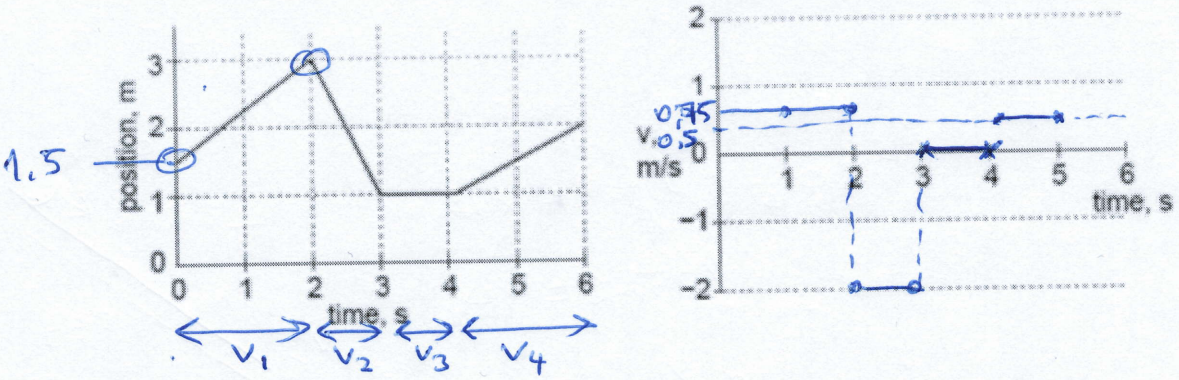
$0 = 30 - 2t$

$t = \frac{+30}{-2} = 15\,s$

$x_f = 30 \cdot 15 + \frac{1}{2}(-2)(15)^2 = 450 - 225$

$\boxed{x_f = 225\,m}$

5. The left-hand graph below shows the position of an object as a function of time. On the right-hand graph, draw a line representing the velocity of the object.



$v_1 = \frac{\Delta x}{\Delta t} = \frac{3 - 1{,}5}{2} = 0{,}75\,\frac{m}{s}$ $\quad v_3 = \frac{1-1}{4-3} = 0$

$v_2 = \frac{1-3}{3-2} = \frac{-2}{1} = -2\,\frac{m}{s}$ $\quad v_4 = \frac{2-1}{6-4} = \frac{1}{2} = 0{,}5\,\frac{m}{s}$

6.

A jet lands at 80.0 m/s, applying the brakes 2.00 s after landing. Find the acceleration needed to stop the jet within 5.00×10^2 m.

$v_f = 0$ $\quad v_0 = 80\,\frac{m}{s}$ $\quad t = 2\,s$ $\quad \Delta x = 500\,m$

$v_f^2 = v_0^2 + 2a\Delta x$ $\quad a = \frac{v_f^2 - v_0^2}{2 \cdot \Delta x}$

$a = \frac{0 - 80^2}{2 \cdot 500} = \frac{-6400}{1000}$

$\boxed{a = -6{,}4\,\frac{m}{s^2}}$