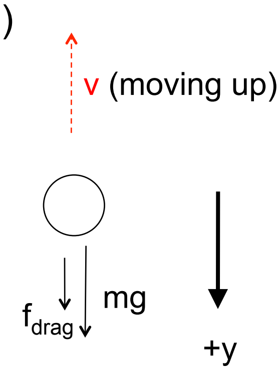
Drag force is: $\vec{f}_D = -b\vec{v} - cv^2\hat{v}$

Consider a mass moving UP
(Let's define DOWN as the +y direction)
Which eq'n of motion is correct?



A) $m\, dv_y/dt = +mg - bv_y - cv_y^2$

B) $m\, dv_y/dt = +mg - bv_y + cv_y^2$

C) $m\, dv_y/dt = +mg + bv_y - cv_y^2$

D) $m\, dv_y/dt = +mg + bv_y + cv_y^2$

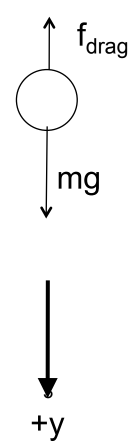
E) Other!

1

Drag force is $\vec{f}_D = -b\vec{v} - cv^2\hat{v}$

(Let's define DOWN as the +y direction)
While moving *up*, the correct expression was:
$m\, dv_y/dt = +mg - bv_y + cv_y^2$

If the object is now moving DOWN,
which term(s) in that equation will change sign?
A) mg (only)
B) the linear term (only)
C) the quadratic one (only)
D) *more* than one term changes sign
E) NONE of the terms changes sign.



Assuming you have two spheres made of the *same material*, but one has a larger diameter. When dropped in air, which one will reach the higher terminal velocity, the bigger one or the smaller one?

A) The bigger one
B) The smaller one
C) both are the same
D) ???

4

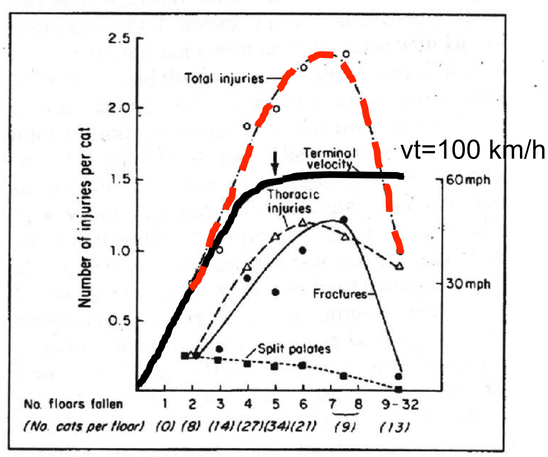


Figure 2—Relationship of injuries to distance fallen and velocity in 132 cats with high-rise syndrome: ↓ points to terminal velocity (——); total number of injuries/cat (○, —·—·—·); number of thoracic injuries (pulmonary contusions +pneumothorax)/cat (△, – – –); number of fractures/cat (●, ——); number of split palates/cat (■, – – – – –).

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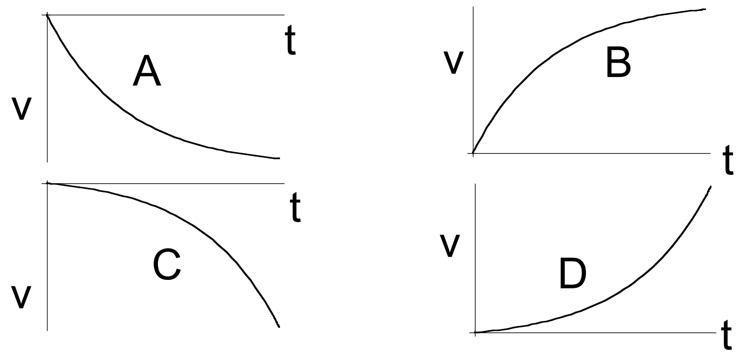
The solution to the equation describing an object falling from rest with linear air drag was

$$v_y(t) = -v_t(1 - e^{-t/\tau})$$

Which figure best shows this sol'n?

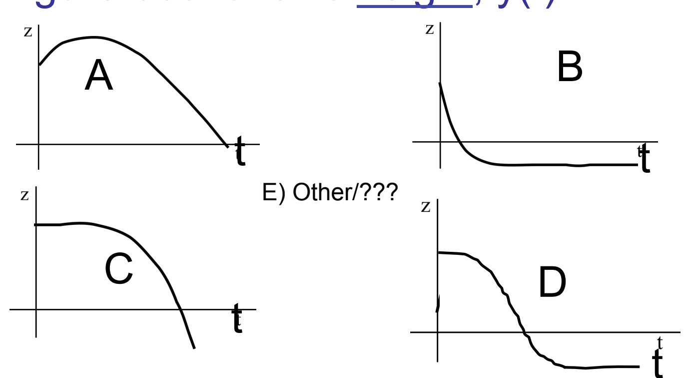


E) Other/???

6

The solution to the eq'n describing an object falling from rest from h>0 with linear air drag was $v_y(t) = -v_t(1 - e^{-t/\tau})$

Which figure best shows <u>height</u>, y(t)?

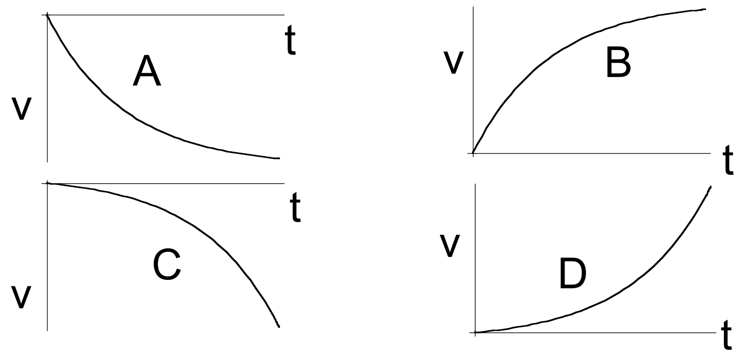


E) Other/???

The solution to the equation describing an object falling from rest with quadratic air drag was

$$v_y(t) = -v_t \tanh(gt/v_t)$$

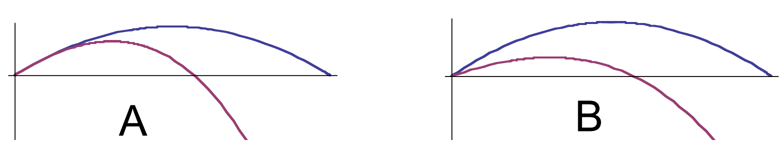
Which figure best shows this sol'n?



E) Other/???

8

Which of these two plots seems more realistic for a tennis ball trajectory, comparing (in each graph) the path with (purple), and without (blue), drag.



C) Neither of these is remotely correct!

9

With quadratic air drag, $v(t)=v_0/(1+t/\tau)$
where $\tau=m/(cv_0)$, and $c=(1/2)c_0 A \rho_{air.}$
(For a human on a bike, c is of order .2 in SI units)

Can you confirm that c is about 0.2? (c_0 is ~1 for non-aerodynamic things, and ~.1 for very- aerodynamic things.

Roughly how long does it take for a cyclist on the flats to drift down from v_0=10 m/s (22 mi/hr) to ~1 m/s?

A) a couple seconds
B) a couple minutes
C) a couple hours
D) none of these is even close.

In real life, the answer is shorter than this formula would imply. Why?

10

An object is launched directly upwards with initial speed v_0.
Compare the time t_1 to reach the top
to the time t_2 to return back to the starting height.

A) $t_1>t_2$
B) $t_1=t_2$
C) $t_1<t_2$
D) Answer depends on whether v_0 exceeds v_t or not.

11

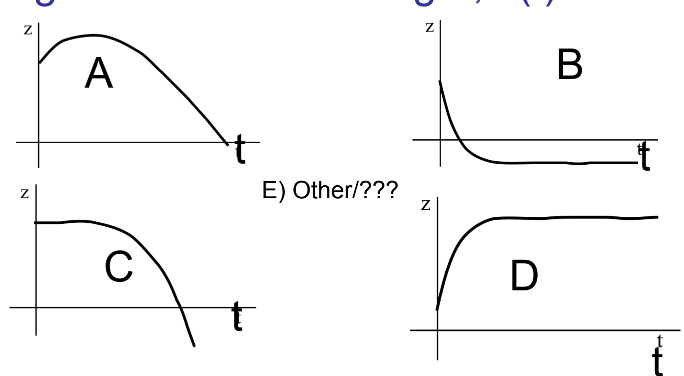
A tennis ball is hit directly upwards with initial speed v_0. Compare the time T to reach the top (height H) to the time and heigh in an ideal (vacuum) world.

A) $T>T_{vacuum}$, $H \approx H_{vacuum}$
B) $T>T_{vacuum}$, $H<H_{vacuum}$
C) $T \approx T_{vacuum}$, $H<H_{vacuum}$
D) $T<T_{vacuum}$, $H<H_{vacuum}$
E) Some other combination!!

The solution to the eq'n describing an object thrown up from h>0 with linear air drag was

$$v(t) = -g\tau + \tau\left(v_0/\tau + g\right)e^{-t/\tau}$$

Which figure best shows height, z(t)?

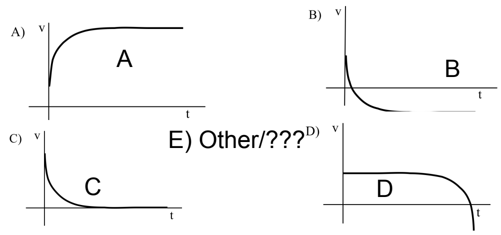


E) Other/???

The solution for an object moving horizontally with linear air drag was

$$v(t) = v_0 e^{-t/\tau} \qquad \text{if } v(t=0) = v_0 > 0$$

Which figure best shows this sol'n?



E) Other/???