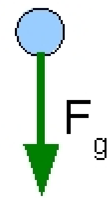
PROBLEM 1 – 10 points

A ball is initially at rest in your hand. You then accelerate the ball upwards, releasing it so that it goes straight up into the air. When it comes down, you catch it and bring it to rest again. Neglect air resistance.

Sketch a free-body diagram for the ball when it is

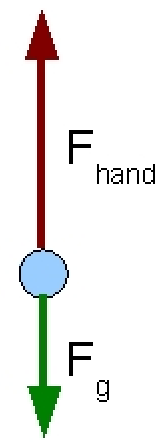


(b) moving up after you release it.

(c) at rest, just for an instant, at the top of its flight.

(d) moving down before you catch it.

In cases (b), (c), and (d), the ball is in free fall. The only force acting on the ball in all three of these cases is the force of gravity.



(a) accelerating upward in your hand.

and

(e) slowing down after it makes contact with your hand again.

In case (a), to give the ball a net acceleration up, your hand exerts an upward force larger in magnitude than the downward force of gravity.

In case (e), the velocity of the ball is directed down but is decreasing in magnitude, which means that the ball's acceleration is directed up. This is the same situation as (a), with your hand exerting an upward force larger in magnitude than the downward force of gravity.

PROBLEM 2 – 10 points

Three identical objects are initially at rest. A constant net force F is applied to object 1 for a time period T, so that it accelerates through a distance D and reaches a speed v.

A constant net force $2F$ is applied to object 2 for a time period T (the same time as for object 1).

[2 points] (a) What is the speed of object 2 at the end of its acceleration period?

[ ] v [ ] $\sqrt{2}\,v$ [**X**] $2v$ [ ] $4v$

Doubling the force doubles the acceleration. With no initial speed, the final speed is equal to the acceleration multiplied by the time. The time is the same, so doubling the acceleration doubles the speed.

[3 points] (b) What is the distance traveled by object 2 during the acceleration period?

[ ] $D/2$ [ ] D [ ] $\sqrt{2}\,D$ [**X**] $2D$ [ ] $4D$ [ ] D^2

Show some work here: **One way to do this is to say that the distance covered is the average speed multiplied by the time. The time is the same, but the average speed has doubled for object 2, so the distance traveled also doubles.**

A constant net force $2F$ is also applied to object 3, accelerating it through a distance D (the same distance as for object 1).

[2 points] (c) What is the speed of object 3 after accelerating through a distance D?

[ ] v [**X**] $\sqrt{2}\,v$ [ ] $2v$ [ ] $4v$

Again, doubling the force doubles the acceleration. With no initial speed, the final speed is related to distance via $v^2 = 2aD$**. For object 3, we have:** $v_3^2 = 2(2a)D = 2v^2$**.**

Taking the square root of both sides gives $v_3 = \sqrt{2}\,v$

[3 points] (d) How much time does it take object 3 to accelerate from rest through the distance D?

[ ] $T/4$ [ ] $T/2$ [**X**] $T/\sqrt{2}$ [ ] T [ ] $2T$ [ ] $\sqrt{T}$

Show some work here: **For object 1, with no initial velocity,** $D = \frac{1}{2}aT^2$, so $T^2 = \frac{2D}{a}$**.**

For object 3, we have $D = \frac{1}{2}(2a)T_3^2$, so $T_3^2 = \frac{2D}{2a} = \frac{T^2}{2}$

Taking the square root of both sides gives $T_3 = \frac{T}{\sqrt{2}}$.