Learning Assistants in the Physics Classroom

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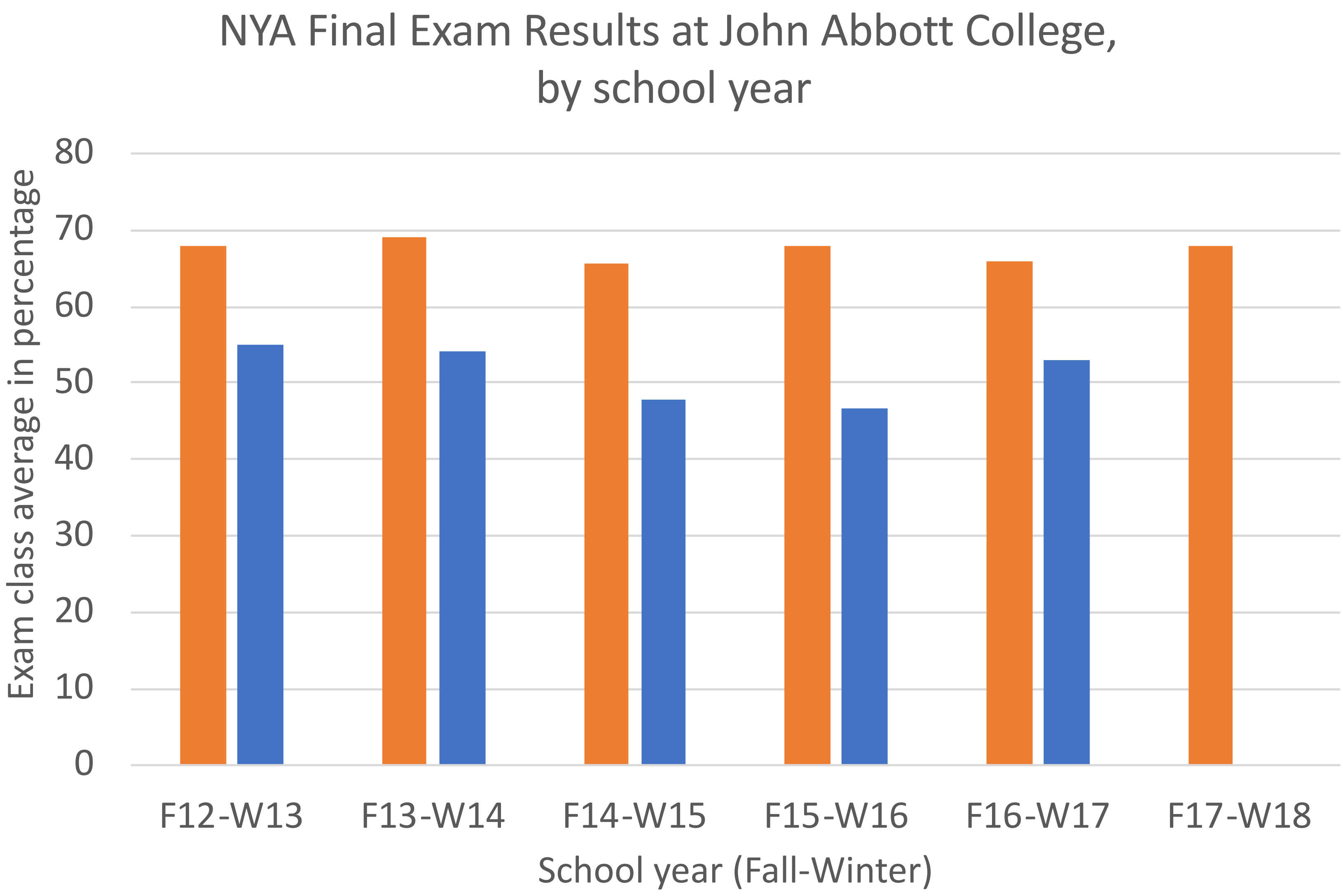
SALTISE, May 31 2018

The context

Semester-year	Pass rates in percent
W17	73%
F17	91%



The Project

- In-class peer tutors, once a week
- Paid student tutor honorarium or hours recognized in Student Involvement Recognition program
- Focus on problem solving

203-NYA-EN: Enhanced Mechanics
Drawing Free-Body Diagrams

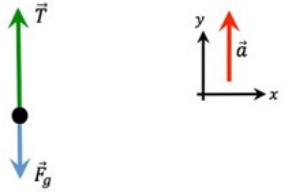
Here are the steps to follow when drawing a free-body diagram (FBD):

1. Identify the object you wish to study.
   1. Model the object as a particle *represented by a dot*.
2. Identify all forces **acting on** the object.
   1. Draw & label vectors representing each of the identified forces, with the tail of the vector placed on the particle.
      → Contact forces are exerted by other objects (ropes, springs, or surfaces) that touch it.
      → Gravitational force (the only long-range force) applies for all massive objects.

For each of the following situations:

a) Draw the FBD for the underlined object.
b) Draw the acceleration vector.
c) Draw your coordinate system
   → A wise choice is to draw one axis parallel to the acceleration vector.
d) According to Newton's 1st & 2nd laws, write down the equations for the forces acting in the *x* & *y*-direction.
   → Clearly indicate/separate what happens in each direction.

Example - An elevator, suspended by a cable, *speeds up* as it moves upward from the ground floor.



In the *x*-direction:

$$\sum F_x = ma_x = 0$$

In the *y*-direction:

$$\sum F_y = ma_y$$

$$T - F_g = ma$$

[1] Jon Snow straps a small model rocket to a block of ice and shoots it across the smooth surface of a frozen lake. Friction is negligible.

[2] A towrope pulls a skier up a snow-covered hill *at a constant speed*.

[3] You have just thrown your physics textbook out the window and it falls straight down at a *steadily increasing speed*.

[4] A steel beam, suspended by a single cable, is being lowered by a crane at a *steadily decreasing speed*.

[5] A jet plane is *accelerating* down the runway during take-off. Friction is negligible, but air resistance is not.

[6] An elevator, suspended by a single cable, has just left the tenth floor and is *speeding* up as it descends toward the ground floor.

[7] A rocket is being launched straight up. Air resistance is not negligible.

[8] A Styrofoam ball has just been shot straight up. Air resistance is not negligible.

[9] You are a rock climber going upward *at a steady pace* on a vertical wall.

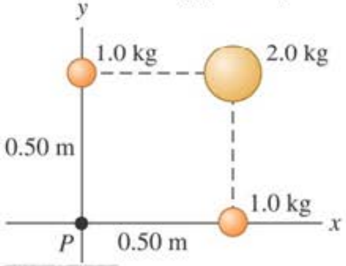
[10] You've slammed on the brakes and your car is skidding *to a stop* while going down a 20° hill.

[11] You have jumped down from a platform. Your feet are touching the ground and your knees are flexing *as you stop*.

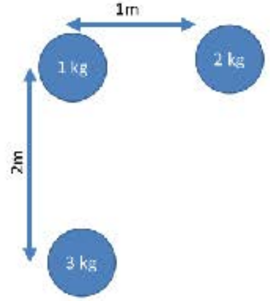
[12] Your friend went for a loop-the-loop ride at the amusement park. Her car is upside down at the top of the loop.

[13] A spring-loaded gun shoots a plastic ball. The trigger has just been pulled and the ball is starting to move down the barrel. The barrel is horizontal.

1. Three uniform spheres are fixed in the position shown in the figure. What are the magnitude and the direction of the force on a 0.0150-kg particle placed at P?

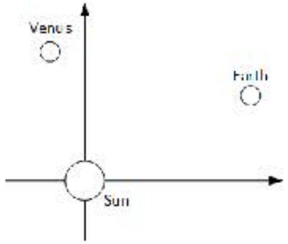


2. Calculate the net force on sphere



3. A uniform sphere with mass 60.0 kg is held with its center at the origin, and a second uniform sphere with mass 80.0 kg is held with its center at the point x=0, y=3.00 m. a) What are the magnitude and the direction of the net gravitational force due to these objects on a third uniform sphere with mass 0.500 kg at the point x=4.00m, y=0. b) Where, other than infinitely far away, could the third sphere be placed such that the net gravitational force acting on it from the other two spheres is equal to zero?

4. Find the coordinates of Venus and Earth in the plane of the ecliptic if the Sun feels a force $\vec{F} = (2.82 \times 10^{22}\hat{\imath} + 2.11 \times 10^{22}\hat{\jmath})N$ due to Earth and a force $\vec{F} = (-1.34 \times 10^{22}\hat{\imath} + 5.38 \times 10^{22}\hat{\jmath})N$ due to Venus.
Mass of Venus 4.87×10^{24}kg
Mass of Earth 5.97×10^{24}kg
Mass of Sun 1.99×10^{30}kg



Answers:
Problem 1: 9.66×10^{-12}N at 45°

Problem 2: Fnet= 1.83×10^{-10}N at 203°

Problem 3a) Fnet 2.20×10^{-10}N at 163°

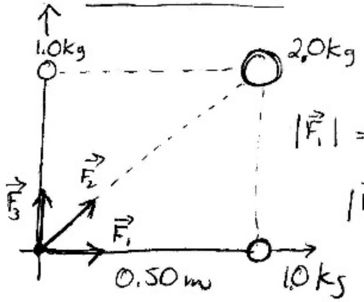
Problem 3b) 1.39 m above the 60 kg mass

Problem 4a) coordinates of Earth (1.20×10^{11}; 9.00×10^{10})m

Problem 4b) coordinates of Venus (-2.61×10^{10}; 1.05×10^{11})m

(3)

Problem 1



$|\vec{F_1}| = |\vec{F_3}| = \frac{G m_p M_1}{r^2}$

$|\vec{F_1}| = |\vec{F_3}| = \frac{6.67\cdot10^{-11}\cdot 0.015 \cdot 1}{0.5^2}$

$|\vec{F_1}| = |\vec{F_3}| = 4.00\cdot10^{-12}$ N

$|\vec{F_2}| = \frac{G m_p M_2}{(0.5^2 + 0.5^2)}$

$|\vec{F_2}| = \frac{6.67\cdot10^{-11}\cdot 0.015\cdot 2}{0.5^2+0.5^2} = 4.00\cdot10^{-12}$ N

$\vec{F_2} = 4.00\cdot10^{-12}\cos 45\,\hat{\imath} + 4.00\cdot10^{-12}\sin 45\,\hat{\jmath}$

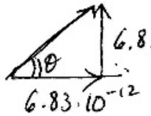
$\vec{F_2} = 2.83\cdot10^{-12}\,\hat{\imath} + 2.83\cdot10^{-12}\,\hat{\jmath}$

$F_{net,x} = 2.83\cdot10^{-12} + 4\cdot10^{-12} = 6.83\cdot10^{-12}$ N

$F_{net,y} = 2.83\cdot10^{-12} + 4.00\cdot10^{-12} = 6.83\cdot10^{-12}$ N

$|\vec{F}_{NET}| = \sqrt{(6.83\cdot10^{-12})^2 + (6.83\cdot10^{-12})^2}$

$|\vec{F}_{net}| = 9.66\cdot10^{-12}$ N



$\theta = \tan^{-1}\left(\frac{6.83\cdot10^{-12}}{6.83\cdot10^{-12}}\right) = 45°$

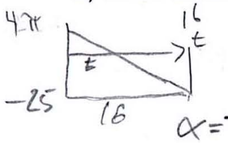
The barrel of a top-loading washing machine has a diameter of 0.75m. It first spins counter-clockwise at a rate of 120rpm. At t = 0 it begins to change its velocity at a constant rate, until, at t = 16s it is spinning at 25rads/s clockwise.

$\omega_0 = 4\pi \quad \omega = -25\ rad/s$

a) What is the total angular displacement over the 16s? ans: -99.2rad

$\theta = \theta_0 + \bar{\omega} t = \left(\frac{-25+4\pi}{2}\right) \cdot 16 = -99.5\ rad$

b) When does it reverse the direction of its spin? ans: t=5.4s



$\frac{4\pi}{t} = \frac{4\pi+25}{16} \rightarrow \frac{64\pi}{4\pi+25} = t$

$\alpha = \frac{-4\pi-25}{16} = -2.35\ rad/s^2 \quad t = 5.35\ s$

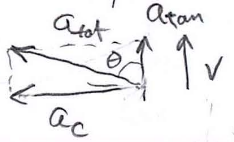
c) What is the acceleration of a sock at t = 8s? (neglect gravity)

ans: a_{tan}=-0.88m/s², a_{rad}=14.4m/s², a_{tot}=14.4m/s² at 86.5° from v_{tan}

$R = 0.75/2 =$

$\omega = \omega_0 + \alpha t$

$= 4\pi + \left(-\frac{(4\pi+25)}{16}\right) \cdot 8 = -6.22\ rad/s$



$a_c = \omega^2 R$

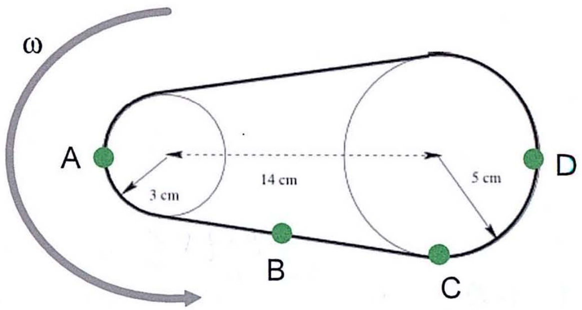
$a_c = 14.49\ m/s^2$

$a_t = \alpha R = -0.88\ m/s^2$

$a_{tot} = 14.5\ m/s^2$

$\theta = \tan^{-1}\left(\frac{14.49}{0.88}\right)$

$\theta = 86.5°$



Two wheels are connected by a belt. Which point is going faster?

A

B

C

D

E they are all going the same speed. (circled)

Which wheel is turning at a faster angular velocity? A

If the wheel with point A is turning at 150 rpm, calculate the linear velocity of the belt and the angular velocity of the wheel with point C on it.

$\omega_A = \frac{v}{r} \Rightarrow v = r\omega_A = 0.03 \cdot 150 \times \frac{1}{60} \cdot \frac{2\pi}{1} =$

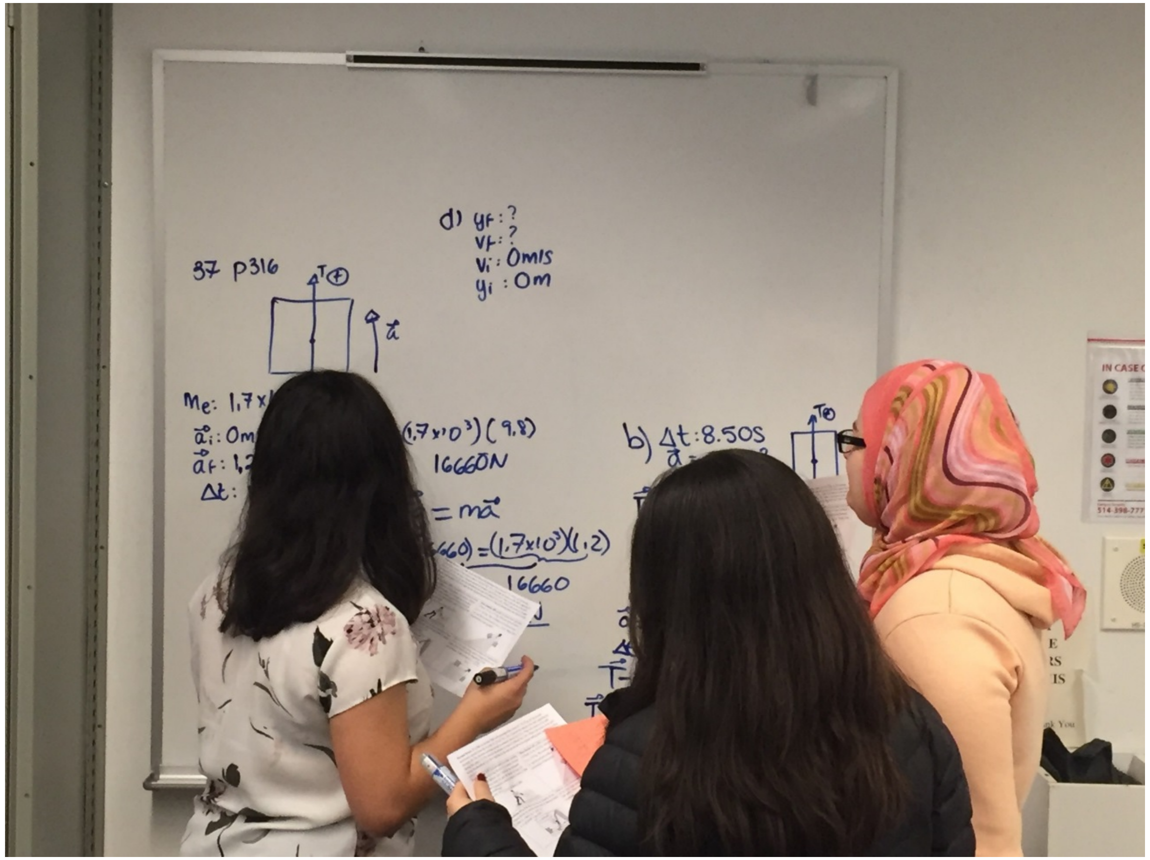
$v = 0.47\ m/s^2$

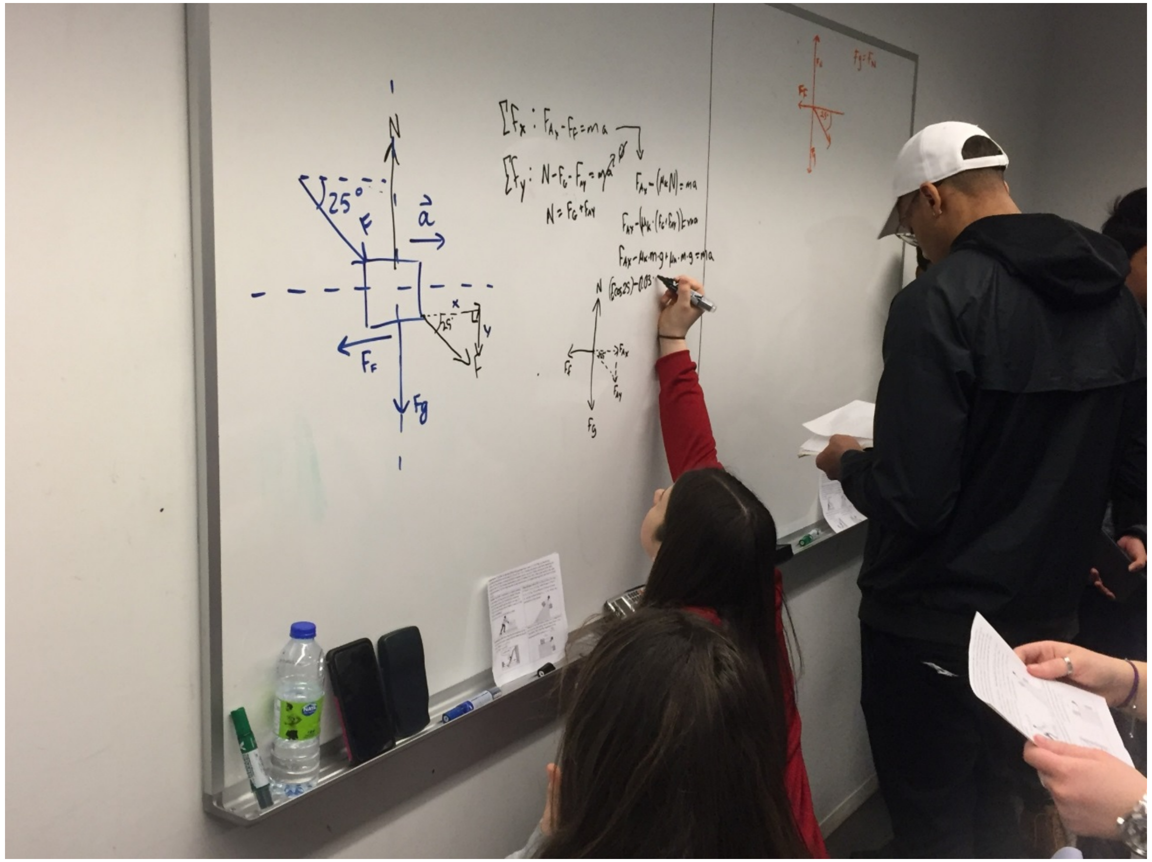
$\omega_c = \frac{v}{r} = 9.4\ rad/s = 90\ rpm$

Seen in lab!

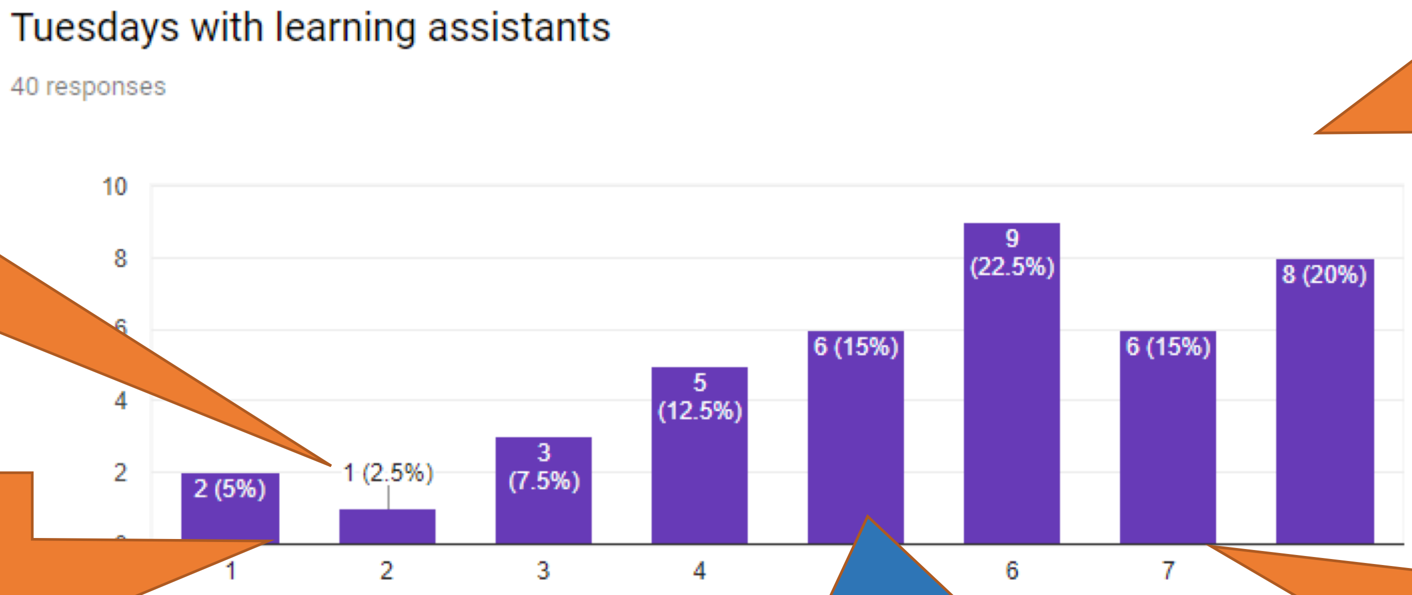
$\frac{\omega_A}{\omega_c} = \frac{r_c}{r_A}$

Classroom atmosphere





Feedback from Etienne’s students on week 4



Disliked

Liked

I would rather you to teach the class before we go into exercises

I like that we're doing examples and that there's help available just wish there was a proper lecture and explanation beforehand

Tuesdays highly depend on the student's before class efforts in the subject. If they did not read and learn by themselves before the class, the class is wasted. The class is useful if students comes in prepared.

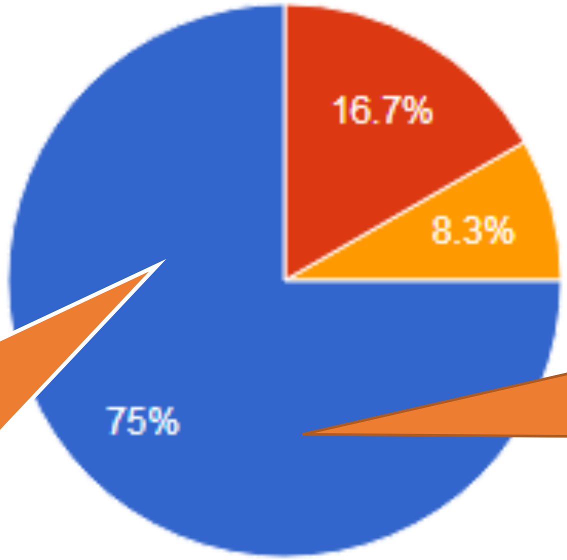
They provide a different aspect of understanding things and you get to work with a group so you can learn new ways of understanding concepts

Instead of being loss on a question, the assistants help to guide us near the answer without actually telling us the answer directly.

Feedback from Caroline's students (end of semester)

Do you think that problems sessions with learning assistants helped you learn?

12 responses



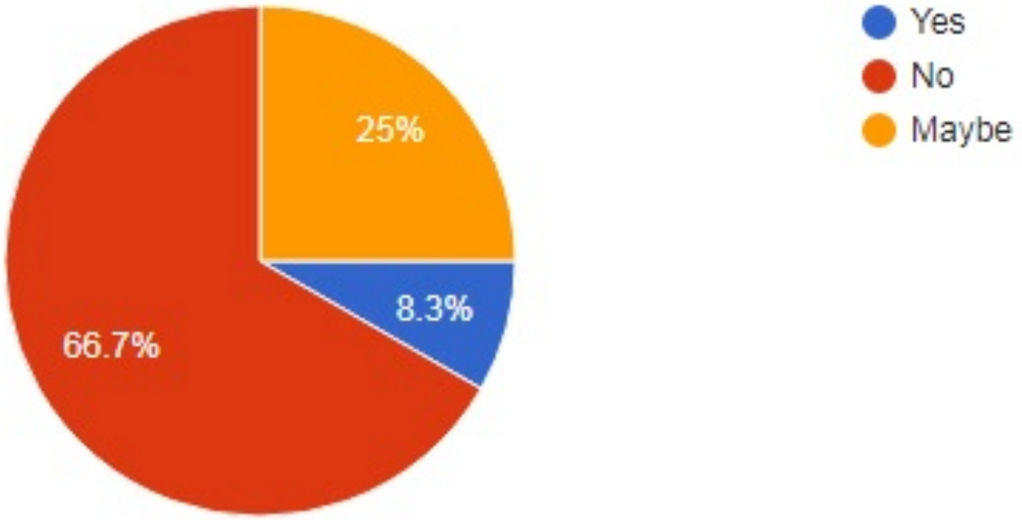
I think it was sometimes easier to reach out for help since they have the same age as we do and it's better sometimes to get explanation from someone that went from doing the same mistakes.

I think this was one of the most innovative ideas I've encountered in all of my years in school. It's one thing to learn the theory but it's the problems that yield the most weight on test and exams so to have a dedicated class period to do so is quite practical and helpful.

Feedback from Caroline’s students (end of semester)

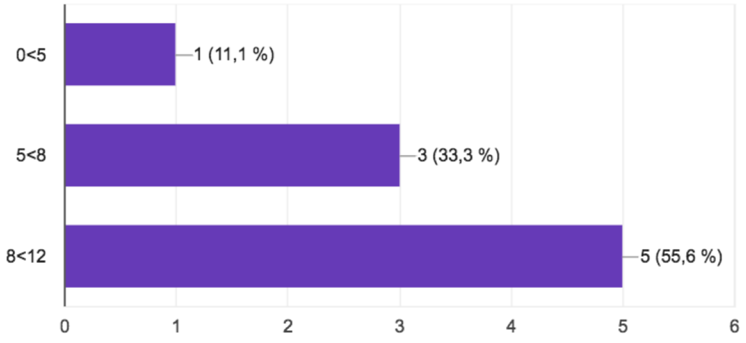
Do you think that reading assignments on Perusall help you learn material?

12 responses

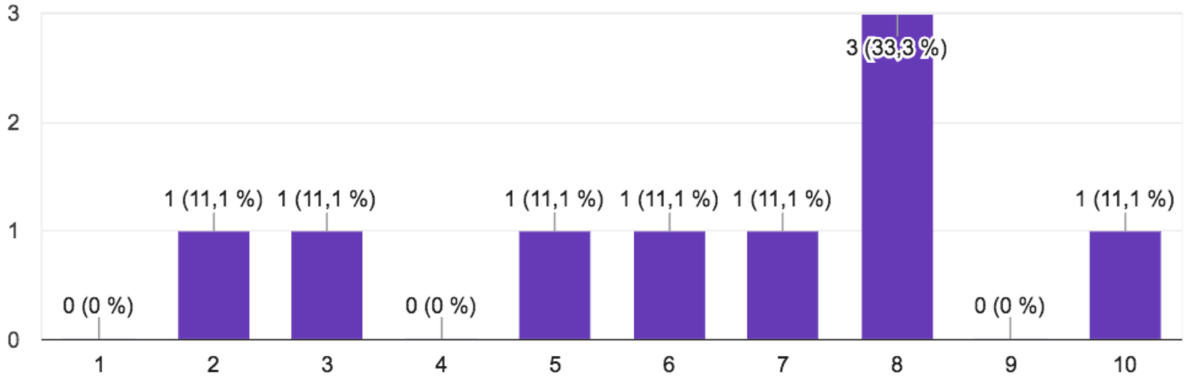


Feedback from Hubert’s students (end of semester)

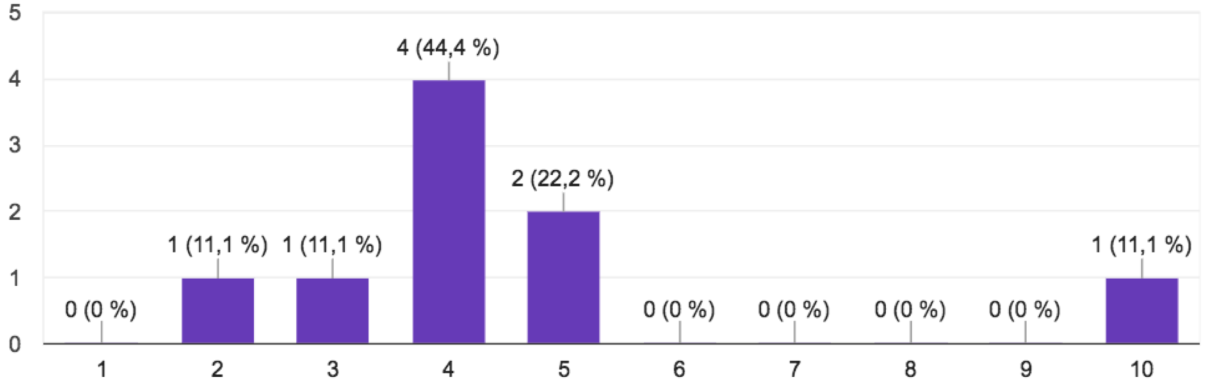
How many Monday's learning sessions have you been to?



Did you like having the learning assistants during our Monday's sessions?



Did the Monday's learning sessions help you learn physics more in-depth?



What would you have improved for these learning sessions?

Doing all the problems together before class ends
Less tutors, more help from the teacher.

Feedback from Hubert's Learning Assistants (end)

What would you have changed in the format of the sessions?

SOLVING PROBLEMS & MORE **TIME**

I would give students x amount of time to solve a problem and then solve the problem with the class. I believe this would be helpful considering that many left without understanding what they did right (when they had the right answer) or without ever solving some problems. Having more time would be great seeing as students often left with the latter challenging problems incomplete.

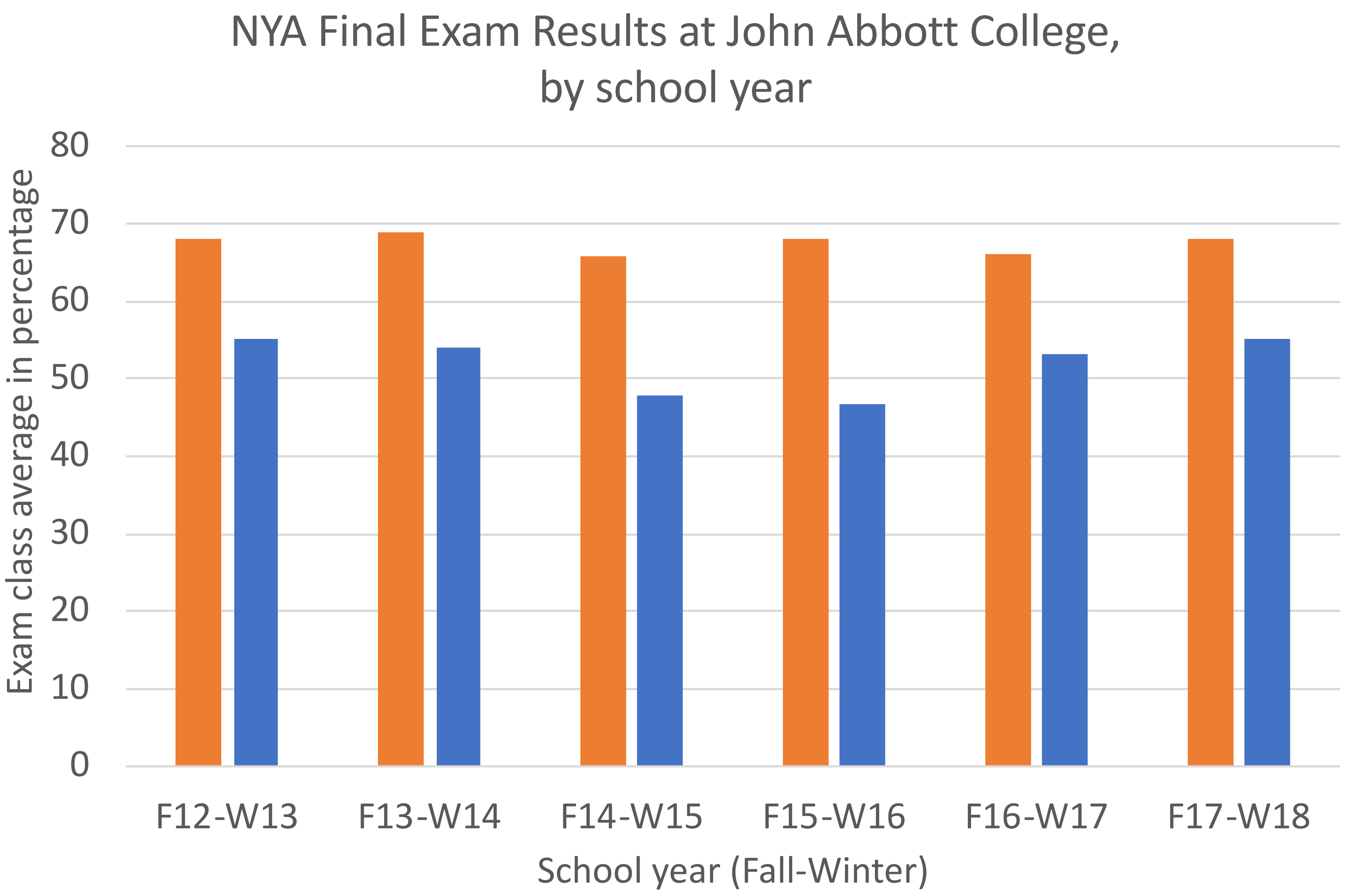
MORE **COMMUNICATION** & MORE **TIME**

I think that if the sessions were a little longer there could be an "open question" period regarding theory questions or problems in general.
There was less communication between learning assistants and teachers which made it difficult to perform at my best.

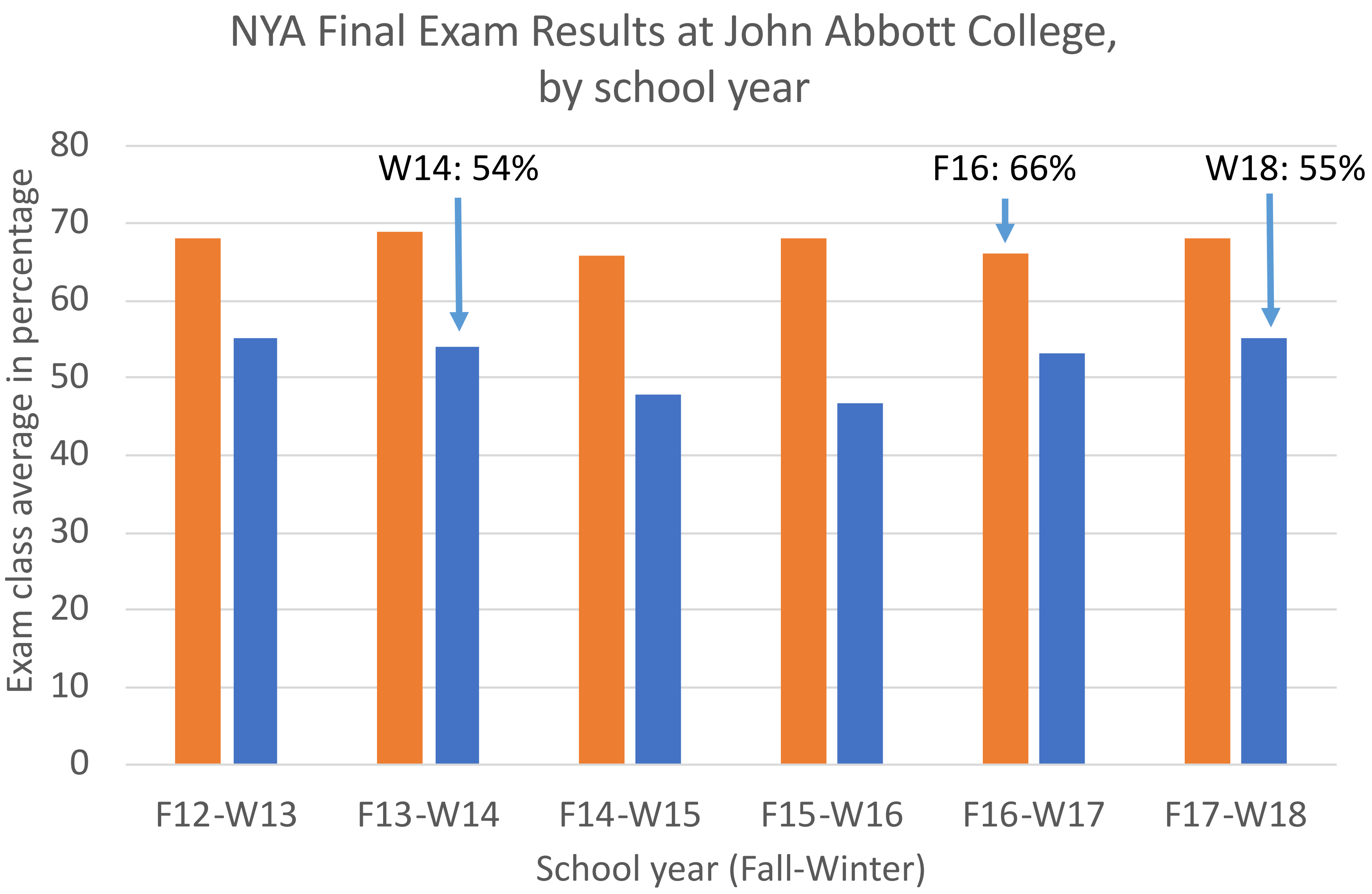
One Major Problem

- ATTENDANCE!

Results

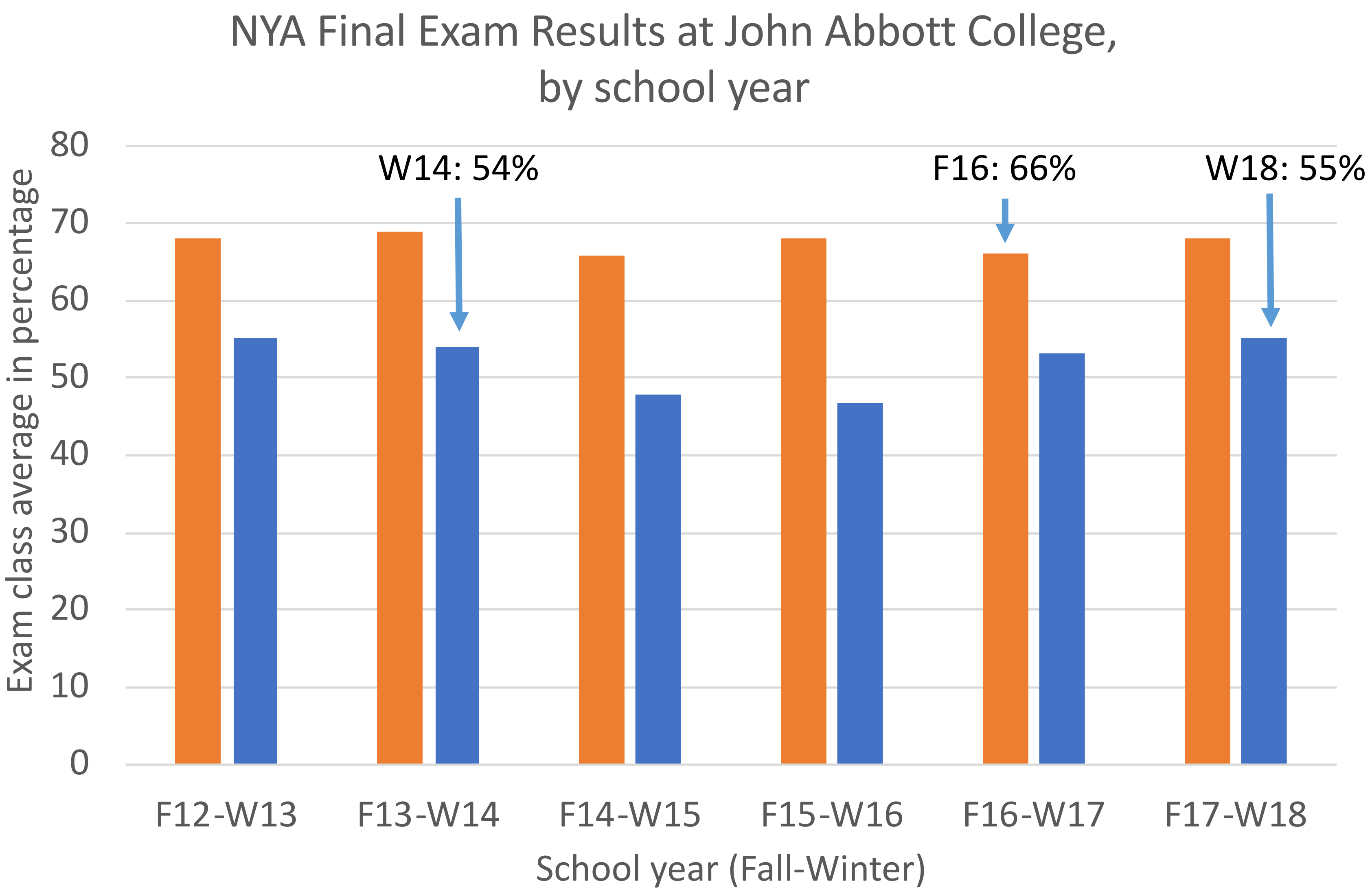

NYA Final Exam Results at John Abbott College, by school year
Exam class average in percentage
80
70
60
50
40
30
20
10
0
F12-W13
F13-W14
F14-W15
F15-W16
F16-W17
F17-W18
School year (Fall-Winter)

Results


NYA Final Exam Results at John Abbott College, by school year
W14: 54%
F16: 66%
W18: 55%
80
70
60
50
40
30
20
10
0
Exam class average in percentage
F12-W13
F13-W14
F14-W15
F15-W16
F16-W17
F17-W18
School year (Fall-Winter)

Results

section	Pass rate
1-2	70%
3-4	74%
5-6	68%
7-8 (remedial)	30%



Way forward