Solving non-traditional problems

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Goals for today

1. Solve the same non-traditional problem in teams and discuss it. What type of problem is it? What will students learn working through it? What are the difficult issues? When should they solve this problem? About 30 min.
2. Solve 2 different individual problems in a team. About 15 min.
3. Share with the rest of the participants and discuss the type of the problem and what the students will learn working through it. About 30 min.
4. Reflection 20 min.

Links.

The document with the problems that we will be working on today

https://docs.google.com/document/d/1ZKdebXzM0My0A0sCBGMmj6nw92qANZVg/edit?usp=sharing&ouid=116596599972817327593&rtpof=true&sd=true

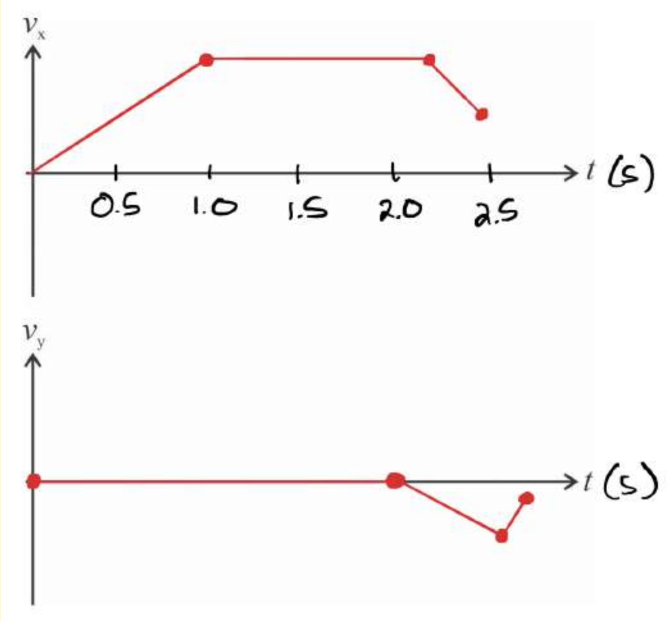
The document with the types of problems to check

https://docs.google.com/document/d/1PKumYBcDPD2gu8aaLZ4DF9kDoCgHWm9m/edit?usp=sharing&ouid=116596599972817327593&rtpof=true&sd=true

Team 1 Problem 0 (Finn's jump) Kinematics

Sketch the graphs on the whiteboard and paste the screenshot here, then proceed answering the rest of the questions

(b) We assumed the runner slowed down when hitting the water. We thought the jumper was slowing down as they entered the water.



Team 1 Problem 0 (Finn's jump) Kinematics

Sketch the graphs on the whiteboard and paste the screenshot here, then proceed answering the rest of the questions

(c)

Pier

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{4\,m/s - 0\,m/s}{2.1\,s} = 1.9\,m/s^2 \approx 2\,m/s^2$$

$$a_y = \frac{\Delta v_y}{\Delta t} = 0\,m/s^2$$

Falling

$$a_x = \frac{\Delta v_x}{\Delta t} = 0\,m/s^2$$

$$a_y = \frac{\Delta v_y}{\Delta t} = \frac{-5.2\,m/s - 0\,m/s}{0.7\,s} = -7.4\,m/s^2$$

Team 1 Problem 0 (Finn's jump) Kinematics

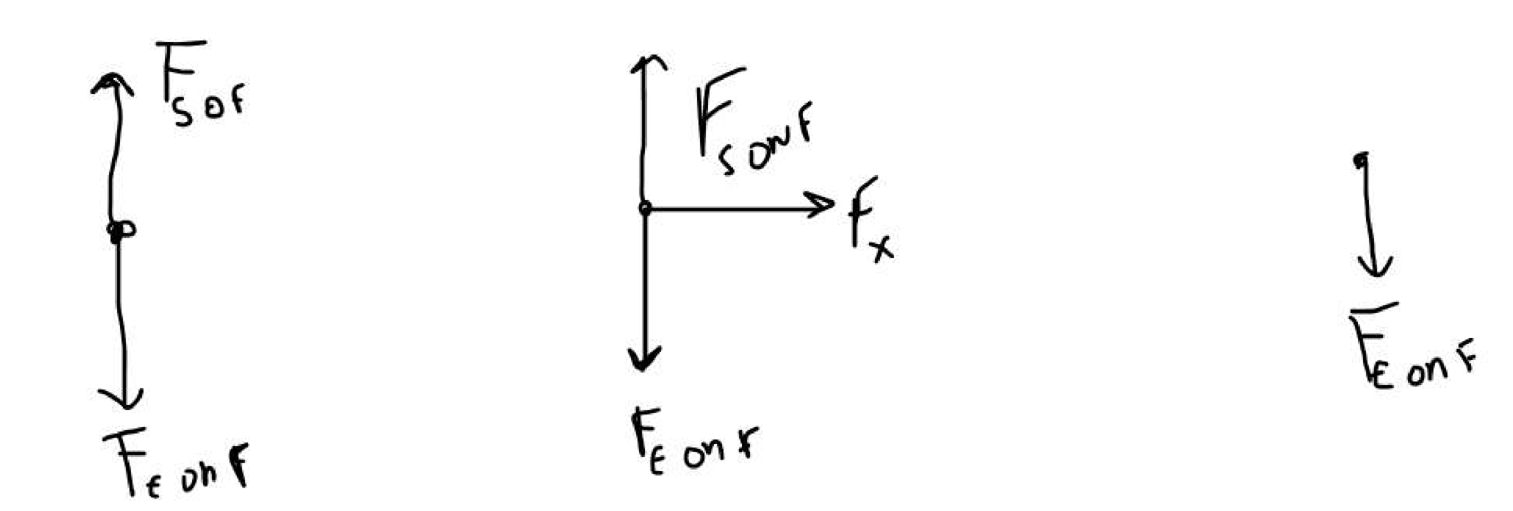
Sketch the graphs on the whiteboard and paste the screenshot here, then proceed answering the rest of the questions

(d) We assumed that Finn was moving at a constant velocity in the horizontal direction for the duration of the jump. We assumed no air resistance or other resistive forces. Also, we estimated the time of the jump to be 0.7 seconds.

$$\Delta x = v_{0_x} t + \cancel{\tfrac{1}{2} a_x t^2} \rightarrow 0$$

$$\Delta x = (4\,m/s)(0.7\,s) = 2.8\,m \approx 3\,m$$

Team 1 Problem 0 (Finn's jump) Dynamics



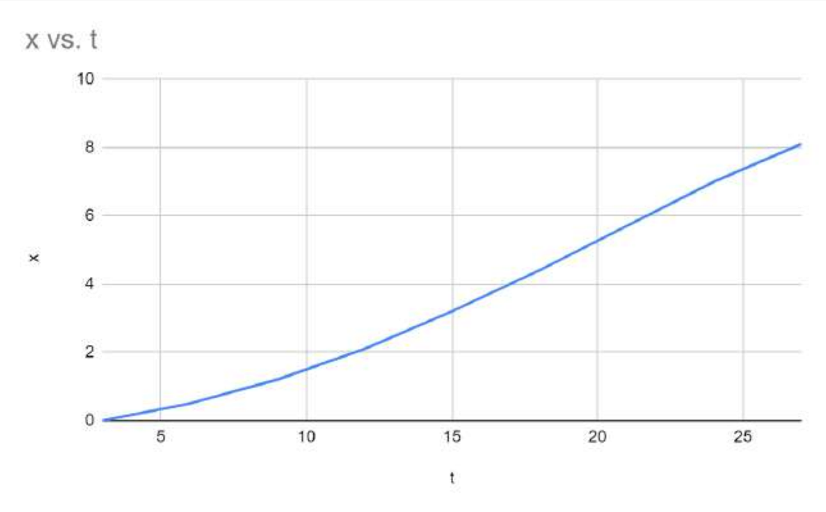
What is Fx? What is the object that exerts this force?

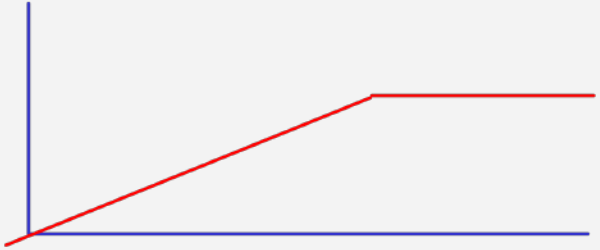
Fx is the frictional force exerted by the ground on Finn.

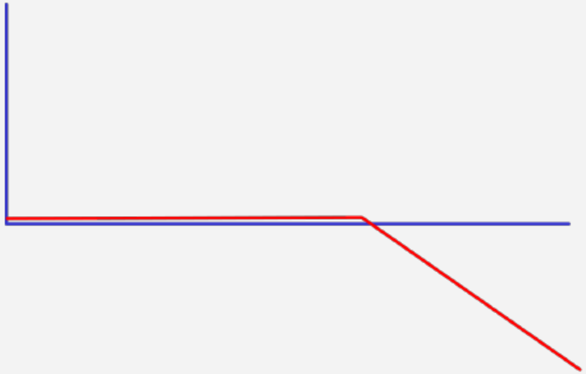
Team 1 Problem 0 (Finn’s jump) Momentum and energy

Team 2 Problem 0 (Finn’s jump) Kinematics

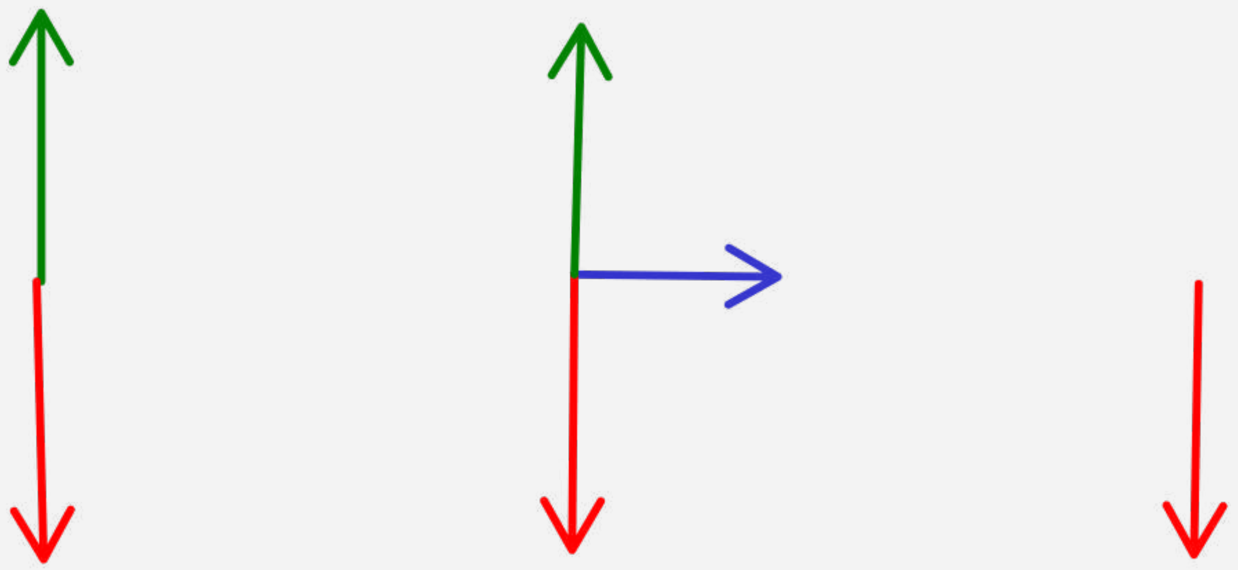
Sketch the graphs on the whiteboard and paste the screenshot here, then proceed answering the rest of the questions





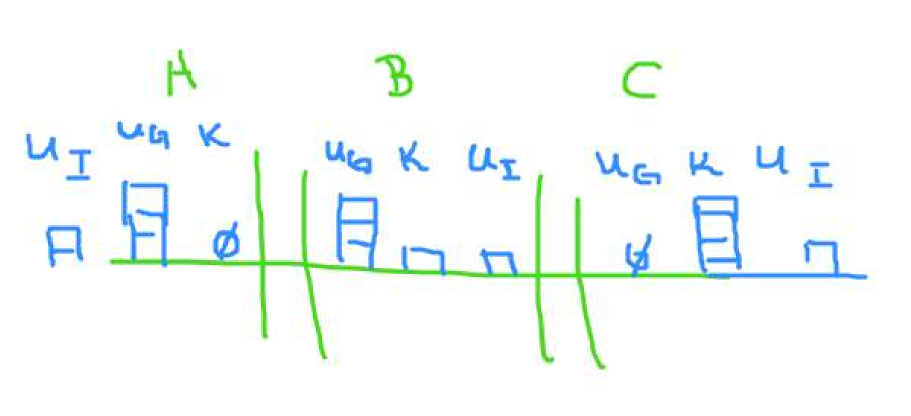


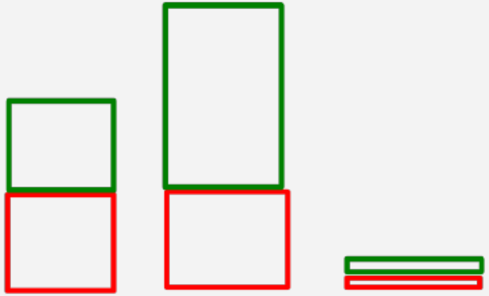
Team 2 Problem 0 (Finn’s jump) Dynamics



Team 2 Problem 0 (Finn's jump) Momentum and energy

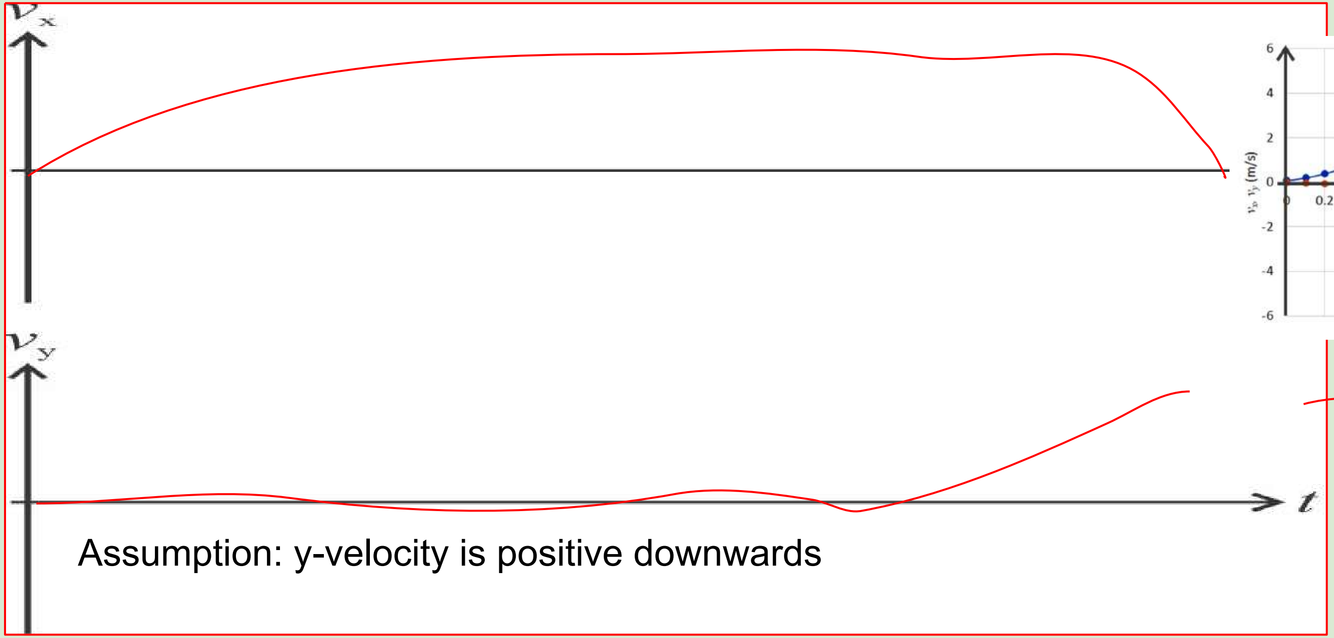
Energy

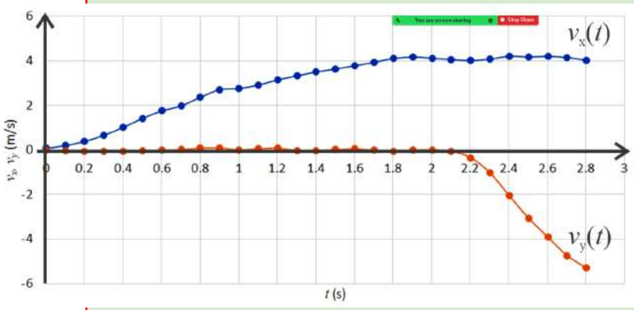




Team 3 Problem 0 (Finn's jump) Kinematics

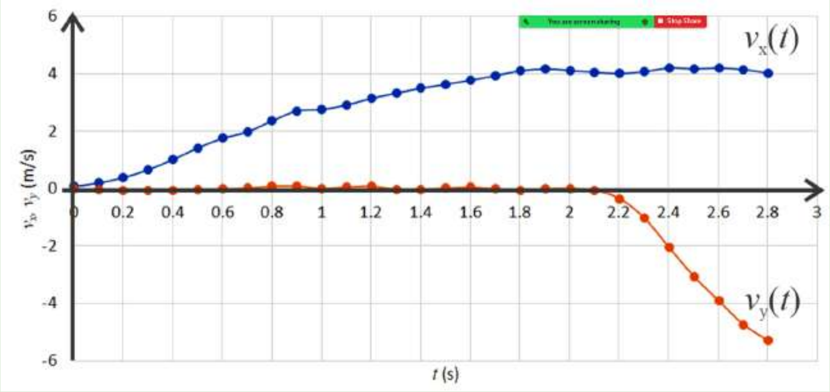
Sketch the graphs on the whiteboard and paste the screenshot here, then proceed answering the rest of the questions





Team 3 Problem 0 (Finn's jump) Kinematics

Using data from the actual velocity-versus-time graphs compare the average magnitudes of Finn's acceleration while he is running along the pier and while he is falling. Which one is larger? How do you know? Are the values reasonable? How do you know?



Acceleration while running is smaller compared to the acceleration while falling.

The acceleration values are **reasonable/not reasonable**. This is because the slope of the velocity-time graph is different at those two times. The velocity along the vertical does not change from 0-2 s, and it is changing from 2.2 to 2.8 s.

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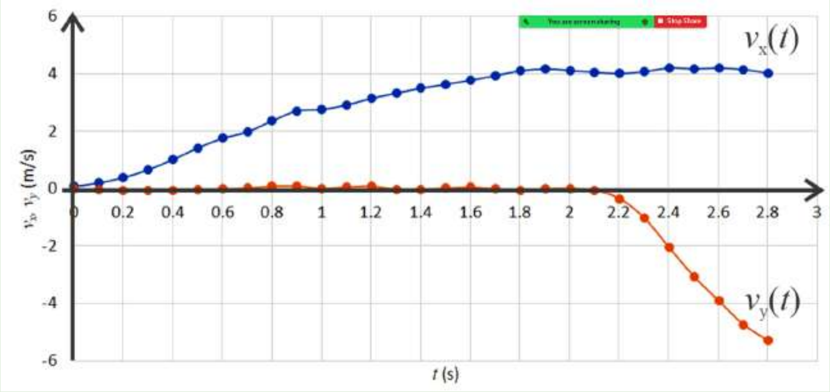
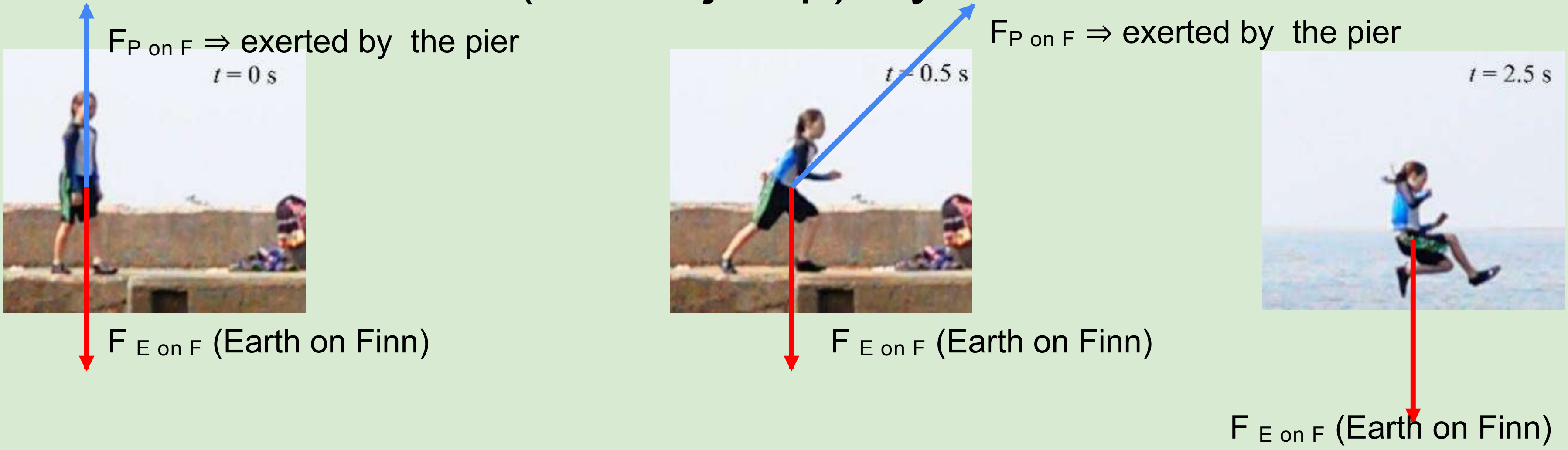
Team 3 Problem 0 (Finn’s jump) Kinematics

Using data from the actual velocity-versus-time graphs and knowing that the distance between Finn’s center of mass and the water level is 2.2 m, determine how far from the pier Finn jumped into the water. Indicate any assumptions that you made.



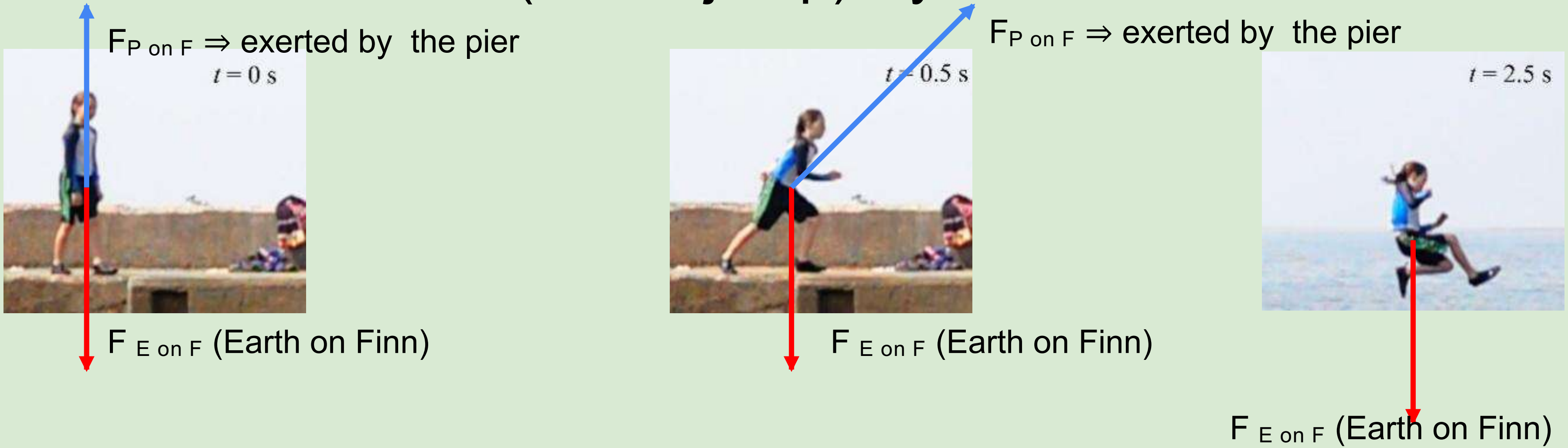
- How far along x-axis (edge of pier) did Finn end up after jumping?
- Time from jump is from 2 s, and touched water at 2.8 s.
- Use this time with v along x-axis to determine horizontal distance

Team 3 Problem 0 (Finn's jump) Dynamics



a. Figures below show Finn at three different times. Draw corresponding force diagrams for Finn below each figure, treating Finn as a point-like object. You may assume that the forces due to air drag are negligible.

Team 3 Problem 0 (Finn's jump) Dynamics



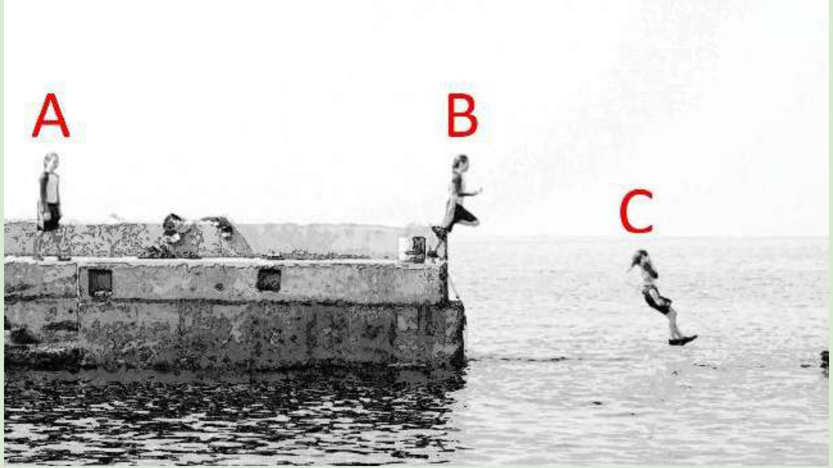
Are your force diagrams consistent with the and graphs (see https://drive.google.com/file/d/15SZnh2IwHAfodD4CGqAQse3P3JIVBhoh/view?usp=sharing)? Explain.

Yes: motion diagram is consistent with graphs. At beginning, the velocity is constant (0). Then the velocity increases on horizontal portion of motion, then at the end, only vertical motion increases.

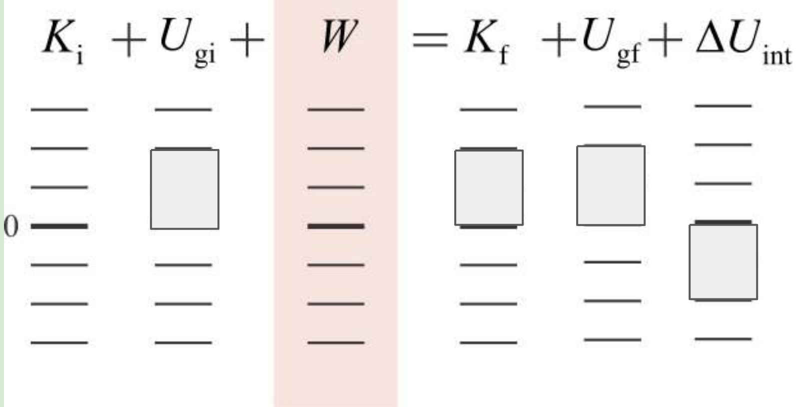
c. Using the graph (see https://drive.google.com/file/d/15SZnh2IwHAfodD4CGqAQse3P3JIVBhoh/view?usp=sharing) and knowing that Finn's mass is 30 kg, estimate the average friction force that ground exerts on Finn at time t=0.5 s.

- Use the mass and acceleration data with Newton's 2nd law
- Use the FBD to determine frictional force, and calculate its value.

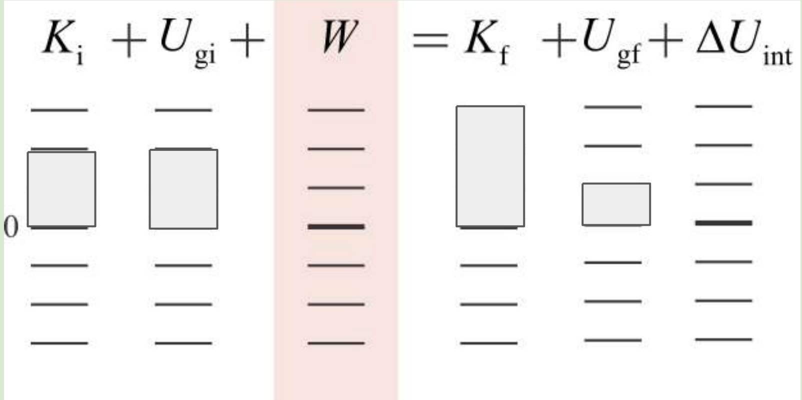
Team 3 Problem 0 (Finn's jump) Momentum and energy



A-B

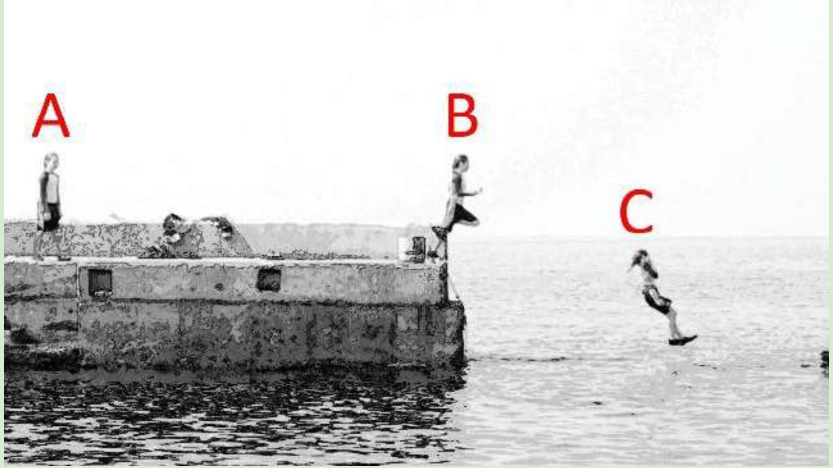


B-C

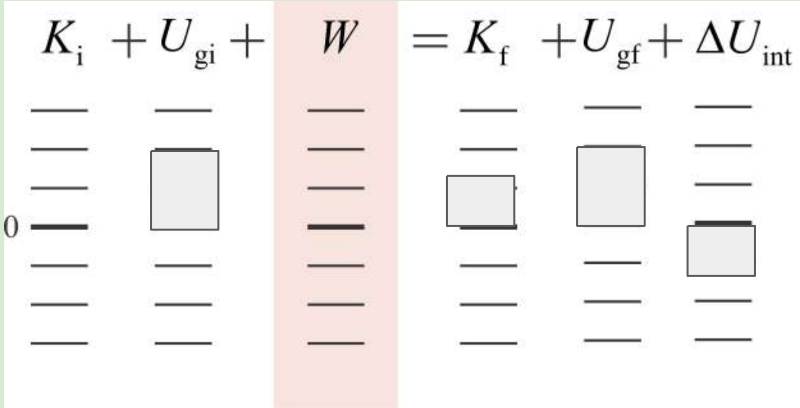


(a) Finn, pier and Earth.

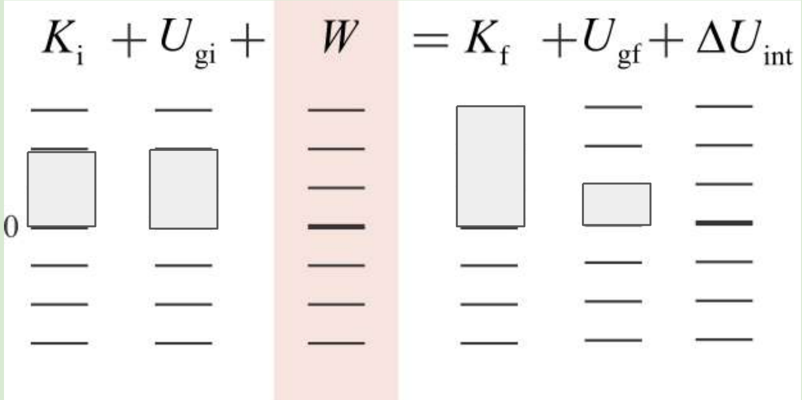
Team 3 Problem 0 (Finn’s jump) Momentum and energy



A-B

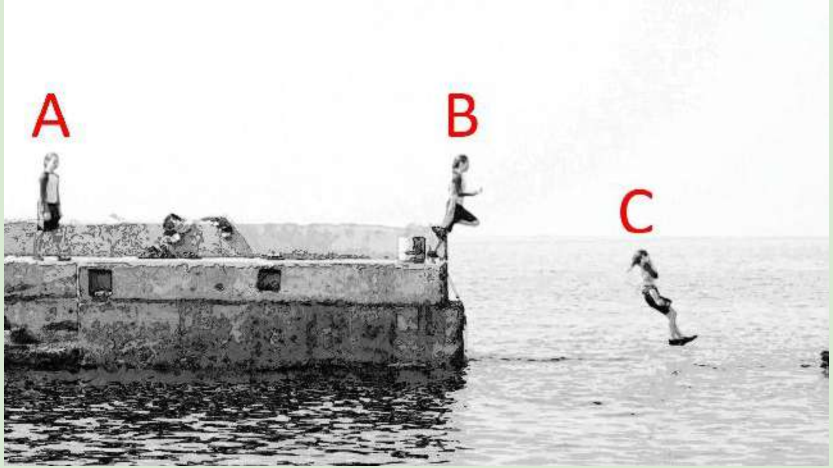


B-C



(a) Finn and Earth.

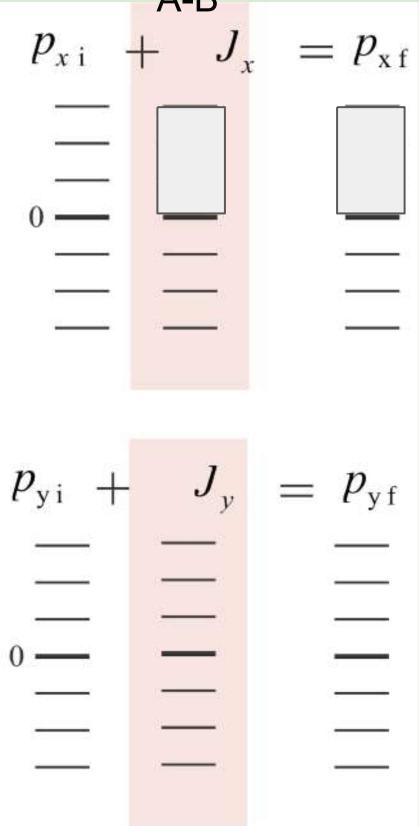
Team 3 Problem 0 (Finn's jump) Momentum and energy



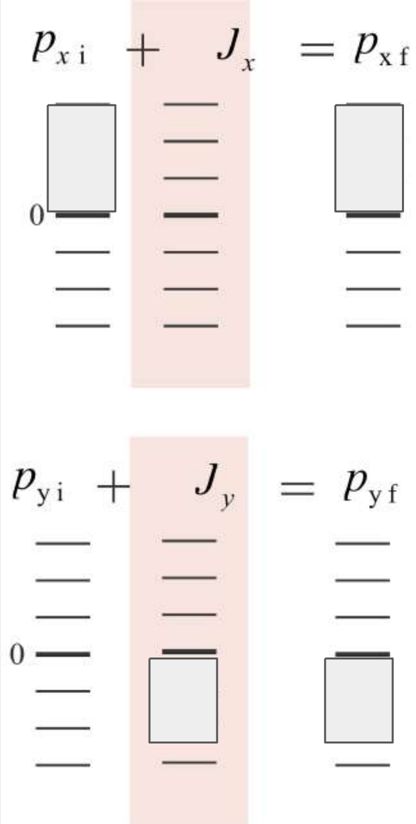
X

Y

A-B



B-C



(b) Let the system consists of Finn only. Draw x and y component momentum bar charts using A as the initial and B as the final state and then another set of momentum bar charts using B as the initial and C as the final state. Make sure that the bar charts are consistent with each other. The template is below.

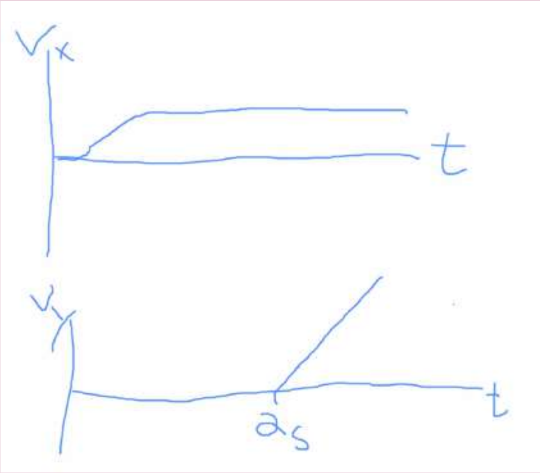
4 Team Problem 0 (Finn's jump) Kinematics

Sketch the graphs on the whiteboard and paste the screenshot here, then proceed answering the rest of the questions

Assumptions:

constant acceleration

Reaches top speed, constant velocity



4 Team Problem 0 (Finn’s jump) Kinematics part b and c

b. Differences:

- Along the x axis, his acceleration was continuous while varying in magnitude until about 2s. On our graph, we had acceleration equal zero after a short time interval. The differences can be explained by accounting for Finn exerting force differently over the course of the run
- Along the y axis, his acceleration was not perfectly constant, but approximately so. Still, drag forces, which we assume are negligible seem to be accounted for in the data.
- Our reference frame has down as positive

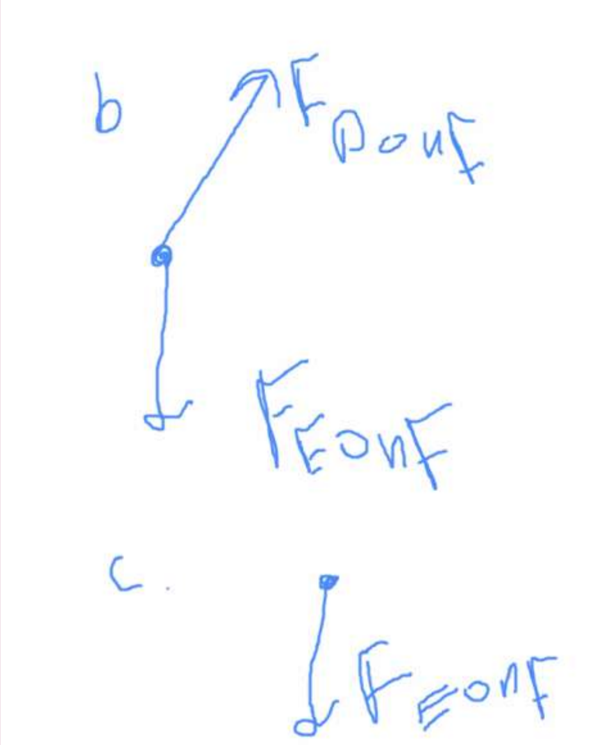
4 Team Problem 0 (Finn's jump) Kinematics part c and d

C. larger acceleration when falling - steeper slope - values reasonable - value of g approx 10.

D. Δx_{Finn}=((2 Δy/g)^.5)*$v_{Finn\ x}$

a

Team 4 Problem 0 (Finn’s jump) Dynamics



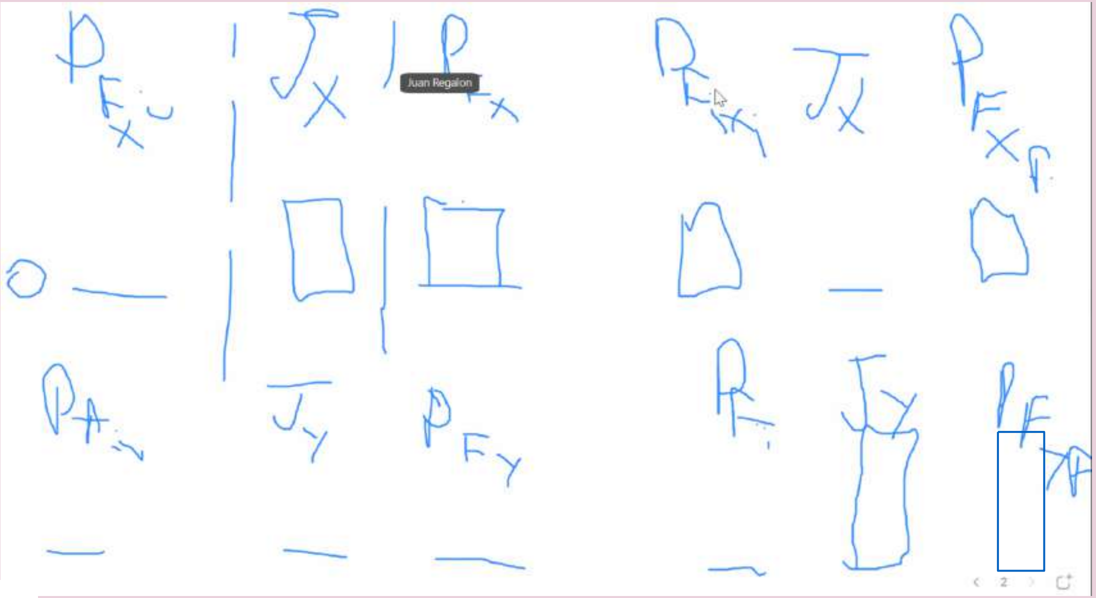
B. Yes, the acceleration values per each graph is consistent with the the sum of the forces as indicated by each force diagram

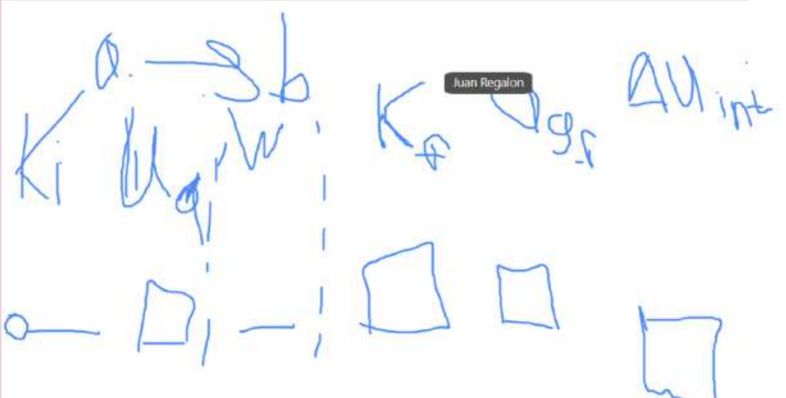
C.a_X = sigma F_X/m F_x = friction force

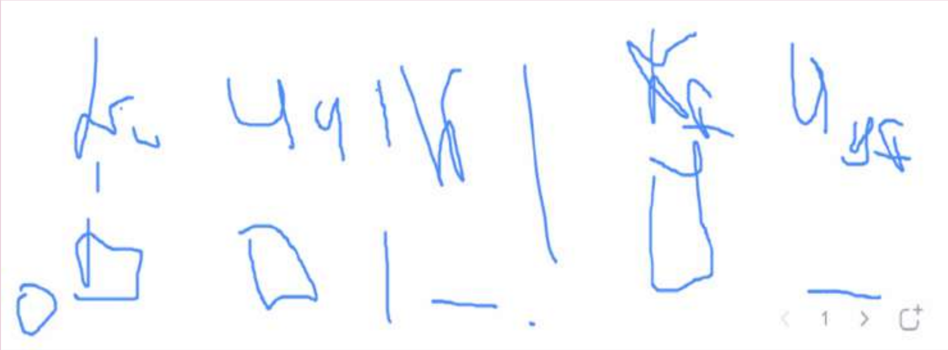
a = delta v /delta t

*$F_{Friction}$=m(delta v/ delta t) = 30kg * (1.5m/s/.5s)=90N*

Team 4 Problem 0 (Finn's jump) Momentum and energy







Team 1 Problem 1 from the document [New problems no solutions.docx]

Answer (C)

Before $R_1 = R_2 = R$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{2}{R}$$

$$R_{eq} = R/2$$

$$I_{battery} = \frac{\mathcal{E}}{R/2}$$

$$I_{battery} = \frac{2\mathcal{E}}{R}$$

$$I_2 = I_1 = \frac{\mathcal{E}}{R}$$

After $R_1 = 2R_2$

$$\frac{1}{R_{eq}} = \frac{1}{2R} + \left(\frac{2}{2}\right)\frac{1}{R} = \frac{3}{2R}$$

$$R_{eq} = \frac{2}{3}R$$

$$I_{battery} = \frac{\mathcal{E}}{\frac{2}{3}R} = \frac{3}{2}\frac{\mathcal{E}}{R}$$

$$I_1(2R) = I_2(R)$$

$$2I_1 = I_2$$

$$I_1 + I_2 = \frac{3}{2}\frac{\mathcal{E}}{R}$$

$$3I = \frac{3}{2}\frac{\mathcal{E}}{R}$$

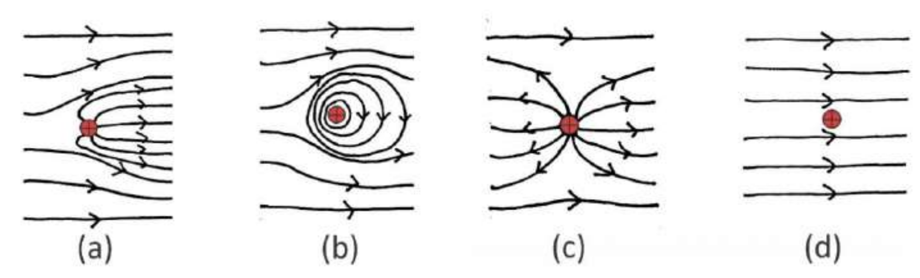
$$I_{battery} = \frac{3}{2}\frac{\mathcal{E}}{R}$$

$$I_1 = \frac{1}{2}\frac{\mathcal{E}}{R}$$

$$I_2 = \frac{2}{2}\frac{\mathcal{E}}{R} = \frac{\mathcal{E}}{R} \rightarrow \text{same as before!}$$

Team 1 Problem 4 from the document New problems no solutions.docx

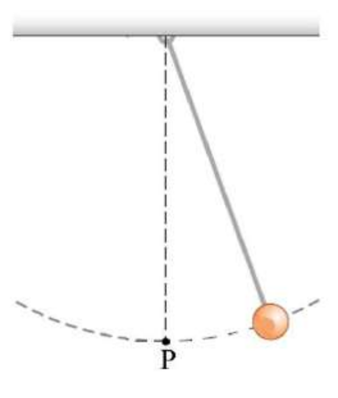
E-field lines initiate on positive charges (left side) and terminate on negative charges (right side). We expect that the E-field lines from the small positive charge will mostly point in the direction towards the negative charge side (towards the right). This is why we think answer choice (a) appears to be the best. Answer choice (b) is incorrect because we do not expect charges to have closed loops for E-field lines. Perhaps the student got confused with magnetic field lines. For (C), the charge should not be pointing as much towards the left unless it possessed a much larger amount of charge. For (d), there are no field lines at all coming from the small charge, which could be an assumption that the student is making if the field from the uniform charged region is much much much larger than the charge of the small positive charge.



Team 2 Problem 3 New problems no solutions.docx

PROBLEM

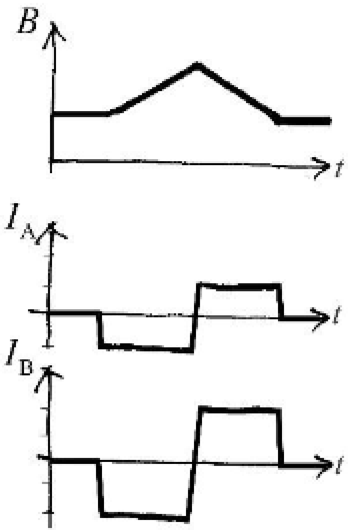
6. A pendulum is swinging back and forth as shown in the figure on the right. What can you say about the acceleration of the bob when it passes point P in the figure? Choose the correct answer with the best explanation.



(a) The acceleration is zero because the speed of the bob when passing point P is maximal.
(b) The acceleration is zero because the sum of the forces exerted on the bob when passing point P is zero.
(c) The acceleration is non-zero and it points vertically up because the sum of the forces exerted on the bob while in constant-speed circular motion points perpendicularly to the trajectory of motion, towards the center of revolution.
(d) The acceleration is non-zero and it points vertically up because the string exerts the maximal pulling force on the bob when it passes the point P.
(e) The acceleration is non-zero and it points vertically down because the sum of the forces exerted on the bob while in constant-speed circular motion points perpendicularly to the trajectory of motion, away from the center of revolution.
(f) The acceleration is non-zero and it points vertically down because the bob exerts the maximal pulling force on the string when it passes the point P.

Team 2 Problem 6 [New problems no solutions.docx]

Team 3 Problem 2 New problems no solutions.docx



2. You found your friends notes that she made about her experiments.

I used two circular loops (A and B) of the same diameter. I placed each loop (one at the time) at the same place in a homogeneous magnetic field so that the direction of the B-field was parallel to the axis of the loop. For each loop I first increased and then decreased the B-field as shown in the top graph. I measured the induced current through the loop. The results are shown in the bottom two graphs. The scales on the horizontal axes of all three graphs are the same and the scales on the vertical axes of the current-versus-time graphs are also the same.

a. Are the current-versus-time graphs consistent with the *B*-field-versus-time graph? Explain.

Faraday's law - induced voltage is proportional to change in magnetic field strength. Combined with circuits - an EMF in a closed loop produces an electric current. Lenz' Law: EMF opposes change in magnetic field

- Shapes are consistent, but does not explain differences in I

b. Propose different explanations for the differences in the induced currents I_A and I_B.

Resistance is different - due to different materials, different cross sectional area, different wire dimensions

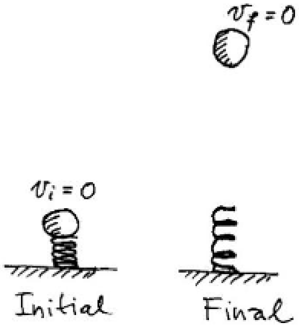
c. What data would you request from your friend to test your explanations?

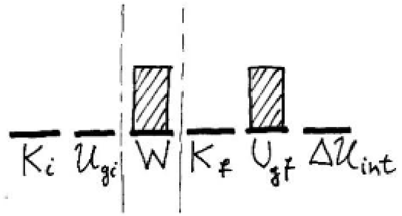
Materials used, resistance of loops, thickness of wires used, cross sectional area of wire,

Team 3 Problem 5 [New problems no solutions.docx]

5. The students were using a small spring to launch a marble vertically up from a table.

Brian presents the following analysis of the experiment: *The system consists of the marble and Earth. The spring is external to the system and does work on it. The initial state is when the marble is resting on a compressed spring. The final state is when the marble reaches the highest point above the table (see sketch on the left). The work-energy bar chart for this process is shown on the right.*





In the analysis I assumed the following:

1) *I ignored air resistance*
2) *I assumed the mass of the spring is negligible*
3) *I assumed the table is very hard so that it does not deform*

a) Which of the assumptions are relevant for Brian's analysis and which are irrelevant? Explain why.
b) Is Brian's work-energy bar chart consistent with the relevant assumptions? Explain.
c) Describe how Brian can validate the relevant assumptions (describe the experiment).
d) Describe how the work-energy bar chart would change if the relevant assumptions are not valid (if necessary, choose a different system).

(a) Irrelevant: table, mass of spring,
Relevant: air resistance

(b) Consistent: v at initial and final positions are the same. W is used to make ball go up, hence U_g increases

(c) A

(d) The same expt with a larger ball will make air resistance not negligible. So the work done is now due to the spring and air resistance, so charts are the same, but bars are longer

Team 4 Problem 7 [New problems no solutions.docx]

a. A is warmer

B. Idea 1: a difference in time connected. One bulb is connected for longer than the other.

Idea 2: Differences in power. Both bulbs may be on for approximately the same time, but the more powerful bulb has a greater energy expenditure. E=P*deltat. Total energy expenditure corresponds to electrical power

c. Data on current and potential difference. The data helps us determine the magnitude of the resistance of each of the bulbs. Likewise we can use data to figure out electrical power

Team 4 Problem 7 New problems no solutions.docx

d. Case 1 and 3 are consistent with the power explanation, using P=IdeltaV, where bulb A, which has a higher potential difference and the same current as B, we would predict it as warmer since it would have a higher energy expenditure.

While the power explanation could work, the explanation that the bulbs were on for separate amounts of time is not rejected by either of these sets of data

For Case 2, the electrical power of each bulb is identical, so the explanation that differences in observed differences are due to differences in electrical power would be rejected by this case.

Conversely, this data does not reject the idea that bulbs were on for separate time periods, so this hypothesis remains plausible from this data set.

Reflection: What did you learn today?

Read the problem carefully. Several times over. Don't make quick assumptions.

Adding in real world problems that can be used throughout multiple units, or as a review

Learned about new types of problems I haven't seen before, hoping to be able to implement more of these types of problems.

Reasoning vs resolving

I learned not to jump to the first answer you think. Learn to ignore your "instinct", which can be biased, and think very carefully about the entire situation. Learn to evaluate your assumptions.

I came in touch so many different problems which are different from the "find the numerical result"