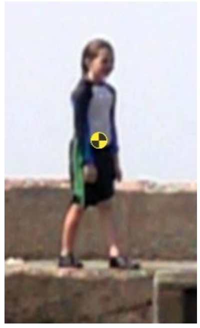
Gorazd Planinsic, University of Ljubljana, Slovenia

and Eugenia Etkina, Rutgers University, USA

0. FINN'S JUMP

The video https://youtu.be/_sCp1igJ3j8 shows Finn running along the pier and then jumping into the sea.

KINEMATICS



a. Draw a qualitative $v_x(t)$ and $v_y(t)$ graphs for Finn's motion, treating him as a point-like object that is positioned at the spot marked on the photo (let's call this point *center of mass*). Indicate any assumptions that you made.

b. Compare your graphs with the actual graphs https://drive.google.com/file/d/15SZnh2IwHAfodD4CGqAQse3P3JIVBhoh/view?usp=sharing that were obtained by tracking the Finn's motion from the video. Do they match? If not, suggest what might be the reasons for the differences (think of the assumptions that you made) and if necessary, revise your graphs.

c. 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?

d. 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.

Then watch the video again and compare the calculated value with the actual value. Do the values match? If not, suggest what might be the reasons for the differences (think of the assumptions that you made).

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.

(a)

(b)

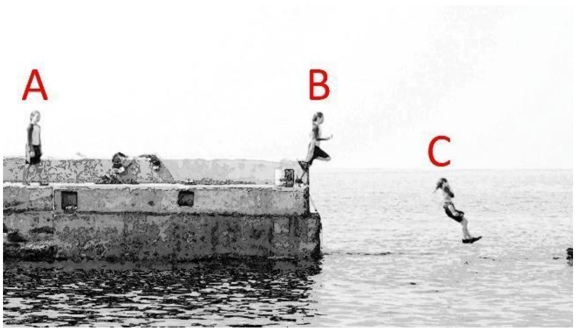
(c)

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

c. Using the $v_x(t)$ 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.

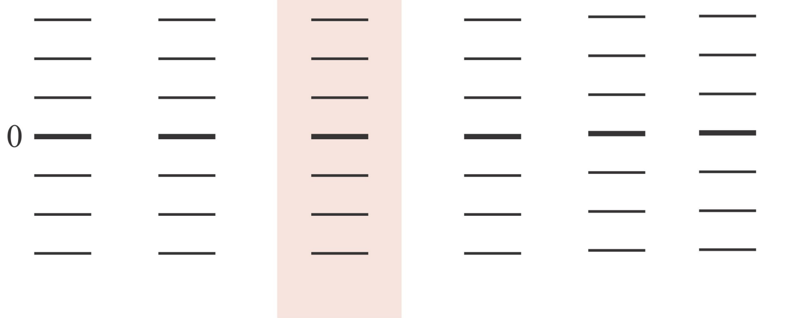
ENERGY AND MOMENTUM

Let the system consist of Finn, pier, and Earth and let's choose the three states A, B and C as shown in the figure below.



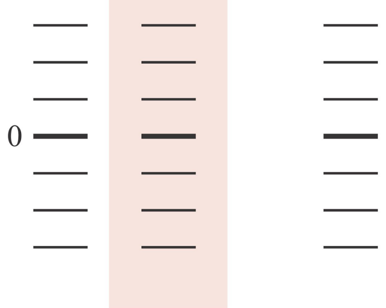
a. Choose your system to be Finn, pier and Earth. Draw a work-energy bar chart using A as the initial and B as the final state and then another bar chart using B as the initial and C as the final state. Make sure that the bar charts are consistent with each other. Repeat for the system of Finn and Earth only. See the template below.

$$K_i + U_{gi} + W = K_f + U_{gf} + \Delta U_{int}$$



b. <u>Let the system consists of Finn only.</u> 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.

$$p_{x\,i} + J_x = p_{x\,f}$$



$$p_{y\,i} + J_y = p_{y\,f}$$