Learning Resources

Details

Completion Time: More than a week
Permission: Download, Share, and Remix

Snow Runways, Fly or No Fly?

Overview
At Summit Station, Greenland, science technicians measure the snow conditions of the runway to determine if the LC-130 aircraft which brings supplies and people in and out of Summit can land and takeoff safely.

Students can use data taken by technicians at Summit Station, Greenland and develop a model to determine if snowpack conditions on the runway are sufficient for the safe takeoff and landing of a fully loaded LC-130. Students can then compare this model with the station manager's decisions.

Some students may have the opportunity to take their own data of soil compacting. Students should compare and contrast their soil data with the snow data provided and also discuss possible models for soilpack and their possible effects on local building codes.

Objectives
By the end of this lesson students should:
1. Understand how to calculate the force on an object due to a mass.
2. Understand how to calculate the gravitational force on an object at a high elevation.
3. Understand how to calculate pressure.
4. Understand phase diagrams and how to interpret them.
5. Understand how to graphically analyze data, plot data, and find trends in data.
6. If doing soil compaction studies, students can use their data to determine whether buildings or other large structures can be safely built at their testing locations.
7. Relate data to operator decisions. How can analytical data be used to support human decisions like whether it is safe for an LC-130 to land and takeoff?

Materials

- Computer with internet access, spreadsheet, presentation and document software
- To recreate these experiments in the soil students will need (per group):
- Plastic or metal pole of known height tapered at one end with centimeter markings at least 50 cm from the bottom. At the top there also needs to be centimeter markings to measure the height from which the weight is dropped. The top of the pole must have a smaller diameter than the bottom of the pole so the weight will not fall beyond a certain point otherwise you will have to catch it.
- 1 or 2 kg mass, preferably one that can slide over the pole.
- Tape or sharpie to mark cm markings on the pole
- Meter stick for marking pole
- Thermometer
- Notebook or computer to record data

Lesson Preparation

- Students can also recreate these experiments in the soil and compare those results with the data give here. Use the materials under the Materials section.

Procedure

After the prelab assignment has been collected and discussed, students should be shown how to use the equipment and be asked to discuss what measurements they need to take to determine the amount of force the snow runway can handle.

For either type of lab (taking your own data or not) the overall goal is to determine the compacting force or pressure of the ice (or soil if taking own data) as a function of depth. Then compare this with the maximum force that the skis of an LC-130 exert per square meter (pressure basically) and determine if the data is consistent with the manager's decisions. Students taking their own data can compare the compacting ability of soil with that of ice and discuss how they are similar/different. I think pressure is better as it eliminates the area of the skis or building if doing soil compacting.

If students are not taking their own data then they need to be given the attached datasets for analysis.

If students are taking their own data outside, teachers should have students develop a research plan for their experiments. Teachers should make sure the students include the following in their research plans

1. Where do you plan to collect your data and why?
2. How many trials do you plan to do and why?
3. What is/are you dependent and independent variables?
4. What conversions or other calculations will you need to do? Do you need to graph the data? (ie, how will students massage the data).

Data Analysis

Graph the Force (N) and/or Pressure (N/m2) on the y axis and the depth (m) on the x axis. Look to see if there are differences between the days the station manager said it was safe for planes and the days when it was not. The station manager really doesn't use this data for this determination, he or she uses surface temperature. See if students can correlate the force vs. depth measurements with surface temperature.

Other data analysis: The area under the curve is work = Energy in Joules, or you can have students create a work vs. depth chart since we know the work done on the rod to pound it into the ground (W = Fd). Students could then determine the average temperature using the energy. They could also determine the energy the skis impart to the snow (or the energy of a building in soil) and see if the ice will undergo a phase change due to the energy added. This might help them to then use their data to determine whether it is safe for the plane to land or takeoff. If the snow undergoes a phase change easily due to the pressure then it will be awhile before the runway will be ready for a takeoff since it must refreeze.

Assessment
Suggested assessment methods are in order of preference.

1. Each student creates a lab report will all relevant parts
a. Abstract
b. Background/Introduction
c. Theory
d. Figures/Illustrations/Balanced Chemical Equations
e. Data and Calculations
f. Summary of Results
g. Discussion
h. Conclusions
i. Recommendations for future work
j. References
k. Post lab questions

2. Students can also choose to do a presentation with the relevant parts listed above.

3. Students can be given a quiz based on the activity.

Teachers note: You can include as much or as little as you like. I've written this for a wide age group.

Extension
n/a

Resources
It is suggested that students be given the following questions as prelab questions and use the Internet or other resources to determine the answers. After each question, a good resource for finding the info is listed.

1. What is the maximum weight of a fully loaded LC-130?
http://www.109aw.ang.af.mil/resources/factsheets/factsheet.asp?id=13101
2. What is the surface area of the skis used on a LC-130?
http://www.109aw.ang.af.mil/resources/factsheets/factsheet.asp?id=13101
3. Determine the gravitational acceleration at 10,500ft.
Universal Law of gravitation….$g = (GM_E)/(R_E+h)^2$
4. How is force calculated? Using the info above, calculate the force all three skis exert on the ground. Then calculate the pressure (N/m) the skis exert on the ground.
$F = mg$….. Pressure is Force/Area

5. At what pressure and temperatures will ice undergo a phase change? How is that important to what we are doing here?
If the ice turns to water during takeoff within 10-20 cm then the plane might not get off the ground or if it's landing and this happens it might not be able to takeoff later.
http://ergodic.ugr.es/termo/lecciones/water1.html
6. Does the South Pole (in Antarctica) have the same issues? Why or why not?
Students should compare the temperatures of Summit Station, Greenland and the South Pole station.

If taking soil compacting data, please add the following questions.
1. How does soilpack differ from snowpack?
2. How can your data be used to determine if it is safe to build a skyscraper at your testing location?

See Appendeces (attached) for sample graphs and photographs.

Credits
ShellyFinley, shellyhynes@yahoo.com/Shelly.Finley.Contractor@usap.gov

National Science Education Standards (NSES)

Content Standards, Grades 9-12

Content Standard A: Science As Inquiry
a. Abilities necessary to do scientific inquiry
b. Understandings about scientific inquiry

Content Standard B: Physical Science
b. Structure and properties of matter
d. Motions and forces
f. Interactions of energy and matter

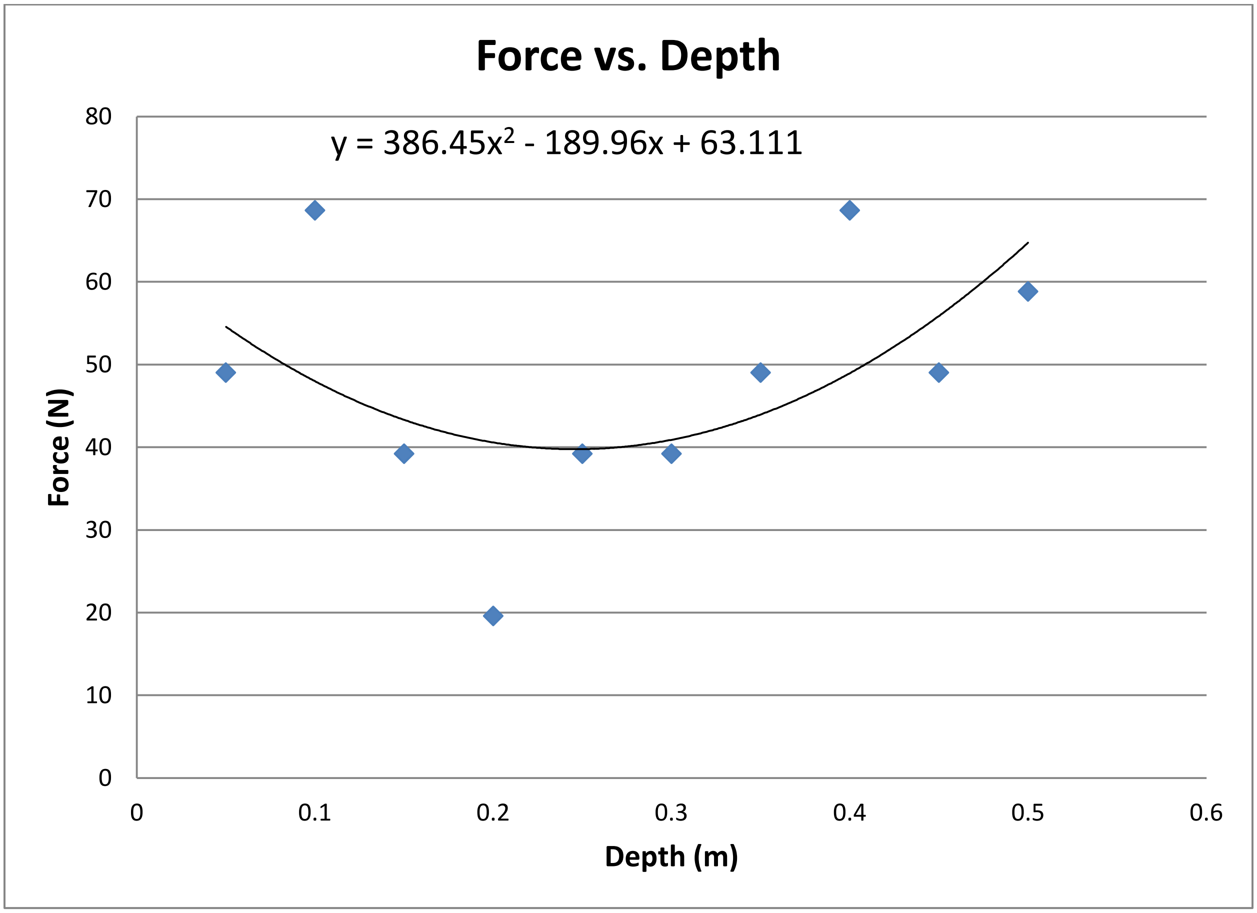
Content Standard F: Science In Personal and Social Perspectives
e. Natural and human-induced hazards

Other Standards
n/a

Appendix A

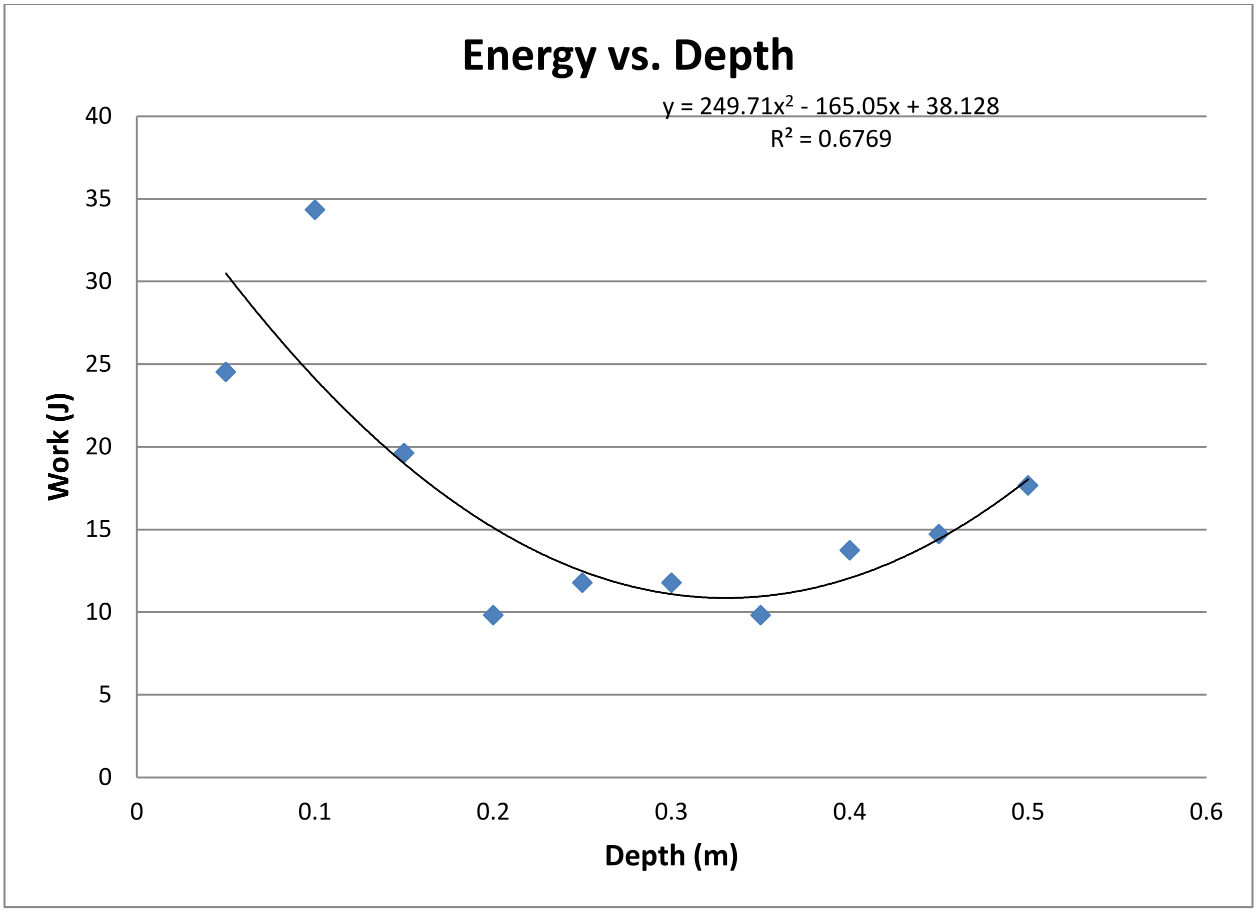
Below are sample graphs of the data

All of the graphs below are samples of what students can do. Two sets of graphs should be created, one on a "good" fly day (snow surface temps around or below 0°) and one on a "bad" fly day (snow surface temps greater than 4°). Compare/contrast the shapes and the "slope" of the graphs, or quadratic coefficients to show a difference on bad vs. good days

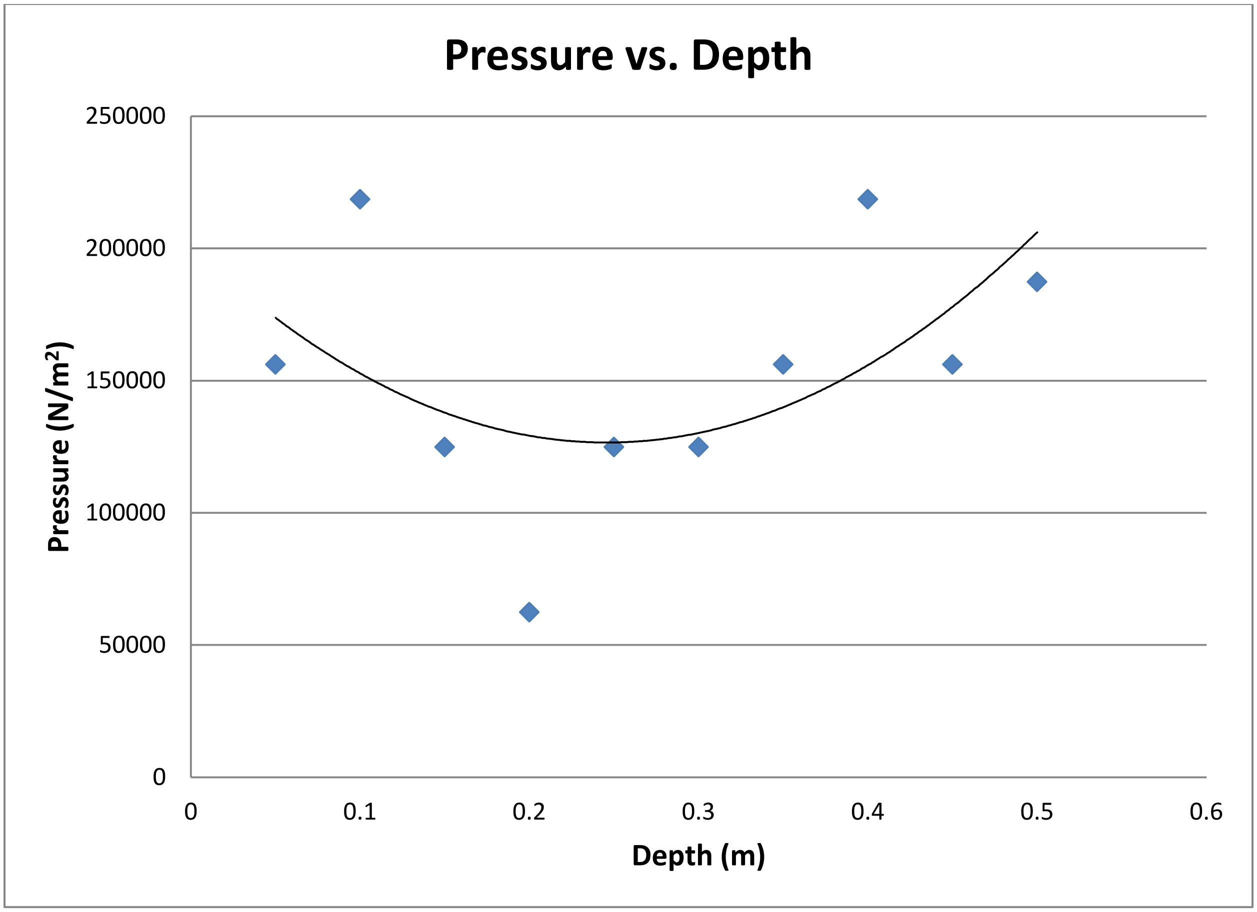


Although there is a high standard deviation, the force vs. depth generally increases as a function of depth which is generally true. Fitting the graph to a polynomial does show the decrease in force after 10 cm and then the rise again which the next graph also illustrates.

Work/Energy vs. Depth



The graph above follows the F vs. Depth, but with much less scattering. Typically the snow is harder at the surface (it has a crust) and then gets softer for awhile but eventually begins to get harder as the weight of the snow compacts the snow. The graph illustrates this very well.



Again, pressure applied vs. depth is increasing. This of course will follow force as they are directly proportional. However, you can calculate the average pressure (or force, whichever you prefer) the skis exert on the snow and see if this value is greater or smaller than the smallest pressure the snow can withstand.

Appendix B

Picture of instrumentation

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Left

# of hits	depth(cm)	height (cm)	Force (N)	Depth (m)	Work (J)	Pressure (N/m^2)
5	5	50	49.05	0.05	24.525	156130.9992
7	10	50	68.67	0.1	34.335	218583.3988
4	15	50	39.24	0.15	19.62	124904.7993
2	20	50	19.62	0.2	9.81	62452.39967
4	25	30	39.24	0.25	11.772	124904.7993
4	30	30	39.24	0.3	11.772	124904.7993
5	35	20	49.05	0.35	9.81	156130.9992
7	40	20	68.67	0.4	13.734	218583.3988
5	45	30	49.05	0.45	14.715	156130.9992
6	50	30	58.86	0.5	17.658	187357.199

Middle

# of hits	depth(cm)	height (cm)

right

# of hits	depth(cm)	height (cm)