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Accelerometer lab series

"Inclined Planes using the TiltTray and smartphone accelerometers"

- teacher notes

Skills and concepts covered in this lab

- understanding accelerometers
    - contact (normal) forces
        - contact forces causing accelerations
        - contact forces on motionless objects (balancing gravitational forces)
    - Simple application of F = ma
    - gravity, "weightlessness", "g-force" concepts
    - optional: Einstein's equivalence principle
- understanding geometry
    - exposure to inclined-plane coordinate systems
    - local vs. global coordinate systems
    - smartphone coordinate systems
        - deducing its structure through real-time display of data
        - choices of positive directions
        - exposure to 3D geometry, "in-out of page" directions
- vector skills
    - breaking vectors into components
    - polar and component form

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Sequencing and Time

- We have suggested the theory "understanding accelerometers" be given to students before the lab, but it can also be read and discussed for the first time during the lab period itself.
- Fits very comfortably in a typical 2-hour lab period.

Notes

Teacher notes: doing all questions during lab time may be hard. Consider doing only the first two diagrams of question 2 and only 2 or 3 rows of question 3, for example.

Sequence/lecture suggestion

- Opening lecture:
  - Smartphone axes nomenclature ; constant even when orientation changes
  - But phone uses just "x y z" nomenclature
    - Try via linear acceleration tests
  - Gravity trick: easier than linear acceleration tests
    - Part 1 of "understanding accelerometers"
  - Accelerometer display: note 3 colored lines, two near zero, one near +-1.
- Lab work (using app, but not TiltTray)
  - "coordinate systems" activity
  - Verify that student can explain reasoning for a given axis
  - Now give access to TiltTray apparatus for next activity
- Lab activity 2 (using TiltTray, but not the app)
  - Examine apparatus with 3 angles
  - Components of g theory exercise (plumb line is gravity direction)
  - Measure critical angle
- Second lecture:
  - g_vec = - a_vec "correct interpretation" horizontal and inclined scenarios
    - i.e. parts 3 and 4 of "understanding accelerometers"
- Lab activity 3 (using TiltTray AND the app together)
  - Work through instructions for Table 2

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Materials

- **the TiltTray apparatus**
  - Designed specifically for this lab.
  - We have a set of 10 TiltTrays ready to bring to your college!

- **Demo material**
  - Ongoing; so far, we have a ball in a box and lots of hand waving.

- **Smartphones**
  - Set up your own! We are getting a few just for use of the accelerometer app in class.