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Accelerometer lab series

"Locating your smartphone's accelerometer using the SpinFrame"

teacher notes

Skills and concepts covered in this lab

- circular motion
    - exclusive focus on "radial acceleration points radially inwards"
    - centripetal acceleration formula
        - NOT used! A purely geometrical approach with no distractions
        - Optional extra step in which its validity could be verified
- understanding accelerometers
    - contact (normal) forces
    - Simple application of F = ma
    - (The lab "Gravity and vectors using smartphones" in this same lab series also covers gravitational concepts which are not necessary here, since all motion occurs in a horizontal plane)
- understanding geometry
    - 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
    - vector components, directions, quadrants
    - translation of vectors
- data interpretation
    - interpreting real-time displays
    - data collection and transfer to spreadsheets for analysis
    - determining average values in time-series data

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The AppTools package

- A set of files to be shared electronically with the students 4-5 days before the lab.
  - Distribute at the same time as the prelab.
- "*AppInstructions.docx*" will oblige them to install the accelerometer app and verify its basic functionality *before* they get to the lab.
- The package includes a sample data file that they must graph and find an average value from.
    - You can optionally request that they present this graph as part of the prelab hand-in.

Materials

- **SpinFrame apparatus**

- **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.

Time

- Fits in a standard 2-hour lab period. If a student is having trouble finishing on time: Only the *data* needs to be collected during the lab time. The rest is analysis, which can be done afterwards.

Suggested Lab Format for a Mini-Report:

- Title, name, date
- Graph of a_x and a_y as a function of time for the first phone position. Make sure to format your axis labels correctly.
- Data table #1.
- Sheet of paper with phone position 1, acceleration components, total acceleration arrow and line traced back.
- Sheet of paper with remaining 3 phone positions, components, arrows and lines
- The placeholder with 4 lines.
- The final position vector.

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Suggestions for “additional investigations”

1. With your phone placed in a position of **your** choice:
   - Predict what acceleration reading will be
   - Repeat Part 2 to verify your results
   - (make sure you keep the phone with the same “ear” orientation)

2. For each quadrant position, you have created an acceleration vector. So far, you have only used the direction of the vector for finding the sensor position. Calculate now the magnitude of each of the 4 acceleration vectors. Use this magnitude, and the known value for the angular velocity, determine the radial value. This radius is the distance from the middle of the circle to the position of the sensor. For each radial line, draw a dot at the radial distance.

3. Coin slipping.
   a. Now for something different. Place a coin on the spin frame at the location of the accelerometer of your phone. Explore what happens when you turn the turntable to the three different speed settings. Record your observations here.

   b. For a single location, and at a speed where the coin does NOT slip, find the value of the force of static friction. Show all of your work.

   c. Can you use the above information to solve exactly for the coefficient of static friction? Explain how you would do this, or explain why it isn’t possible.