Student Views of Similarity between Math and Physics Problems

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Introduction and Methodology

• Part of a larger project studying the intersection of math and physics learning
  • Investigate how students view physics problems in terms of the required mathematical processes
• Students were given a set of physics problems and an analogous set of 'pure' math problems (shown in table below, along with correct answers)

• Data collected over two terms at a small, private, 4-year college.
  • Fall 2010: 18 students   Winter 2011: 17 students
• First semester, calculus-based, introductory physics students

• Grounded theory approach[1] – no existing theory to impose on the data

MATH PROBLEMS	PHYSICS PROBLEMS
A. A certain function is given by the equation $f(x) = 3x^2 - 4x^3 = 6$ At what points are there relative extrema?	a. A time-varying force of $F(t) = 3(t^5 - 5t + 1)N$ pushes a block along a horizontal surface. How much work does the force do on the block in the first 8m of the motion?
B. What is the value of x as given by: $H(x,y,z) = xy + \sin(z) + 4z^2$ if $H = 5.4$, $y = 2.3$, and $z = 0.80$?	b. If the acceleration of a jet ski is given by $\vec{a} = (4t^2 - 8)\frac{m}{s}\hat{i} + (6 - 7t^2)\frac{m}{s}\hat{j}$, find an expression for the jet ski's velocity at any point in time.
C. If the short side of a 30-60-90 triangle has a length of 3, what is the hypotenuse?	c. A projectile is launched upward and covers a distance of 89m in 6.5s. At what initial velocity was the projectile launched?
D. Add the following two vectors: $\vec{s} = 6.6\hat{i} - 5.6\hat{j}$ and $\vec{q} = -9.2\hat{i} - 1.5\hat{j}$	d. Two airplanes are flying in the sky – the displacement of plane A is $d = \sqrt{(5.8t^2 - 2)^2 + (6 - t^3)^2}$ relative to plane B. What is the closest distance that the two planes come to each other?
E. Calculate the area under the curve given by $y(x) = x\sqrt{9 - x^2}$ between x=0s and x=8s.	e. If the vertical component of a car's momentum is 5N and its total momentum is directed at 25° north of east, what is the magnitude of the total momentum?
F. What is the integral of the following function: $g(t) = t^4 + 3t^2\sin(t) - 8t + 2$?	f. Two forces are acting on a block. They are given by $\vec{F}_1 = 3\hat{i} + 2\hat{j}$ and $\vec{F}_2 = -1\hat{i}$. What is the net force acting on the block?

Answers: A-d, B-c, C-e, D-f, E-a, F-b

Results and Conclusions

• Some pairs easily recognizable and explained appropriately:
  • Trigonometry pair (C-e): *'asked to solve for hypotenuse'* (13 of 35) *'requires trig functions'* (13 of 35)
  • Vector addition pair (D-f): directly stated as such (31 of 35)
  • Algebra pair (B-c): *'asked to solve for the missing variable'* (23 of 35)
  • Extrema pair (A-d): *'determining how close is minimization'* (18 of 35) *'set derivative equal to zero'* (6 of 35)

		Math					
		A	B	C	D	E	F
Physics	a	0	1	1	0	22	11
	b	3	1	0	0	11	19
	c	4	27	1	0	0	4
	d	27	3	3	0	2	0
	e	1	3	30	1	0	0
	f	0	0	0	33	0	1

• Integral pairs more difficult for students to distinguish
  • Only 3 students mentioned the limits of integration
  • *'integral is area under curve'* (18 of 35) – not all chose correctly

• In terms of physics interpretations:
  • 11 students correctly cited the relationship between acceleration and velocity, not all chose the correct pairing
  • No student included the relationship between work and force

• Future work: semi-structured interviews to further probe student understanding, using more problem-pairs covering a wider range of topics and with more detail

References

1. Charmaz, K., *Constructing Grounded Theory: A practical guide through qualitative analysis.* Sage: Thousand Oaks, 2006.