

# Work, High School Students, and Horses

or

How to use Interactive Physics to measure the horsepower of an electric motor

# What is a “horsepower”?



# What is Work?

- Khalil works at Wal-Mart unloading trailers and stocking the backroom and shopping floor.
- He gets paid for moving items, sometimes large items, from one place to another.
- The more items he moves, or the further he moves items, the more work he does.

# Interactive Physics Simulation of Work

The screenshot shows a software interface for a physics simulation. The title bar reads "Interactive Physics - [WorkOnSquare]". The menu bar includes "File", "Edit", "World", "View", "Object", "Define", "Measure", "Script", "Window", and "Help". The toolbar contains icons for file operations and simulation controls, including "Run", "Stop", and "Reset".

On the left is a vertical toolbar with various icons for object manipulation. The main simulation area features two vertical sliders: a red "Force" slider with a value of 6.00, and a green "Mass" slider with a value of 7.50. Below these sliders, a small green square with a crosshair is positioned on a blue horizontal surface. A graph titled "Work done on Square" is located in the upper right of the simulation area. The graph's vertical axis is labeled "x (m)" and ranges from 0.0 to 20.0 with major ticks every 5.0 units. The horizontal axis is labeled "t (s)" and ranges from 0.0 to 10.0 with major ticks every 5.0 units. The graph area is currently empty.

To the right of the graph, there are three paragraphs of text:  
"Run the simulation of a force being applied to an object to move it across a surface."  
"Change the force on the square and the mass of the square using the vertical sliders."  
"Answer the questions on your worksheet using this simulation."

At the bottom of the window, a status bar shows the coordinates "x: 0.000 m y: 0.000 m" and a "Ready" indicator.

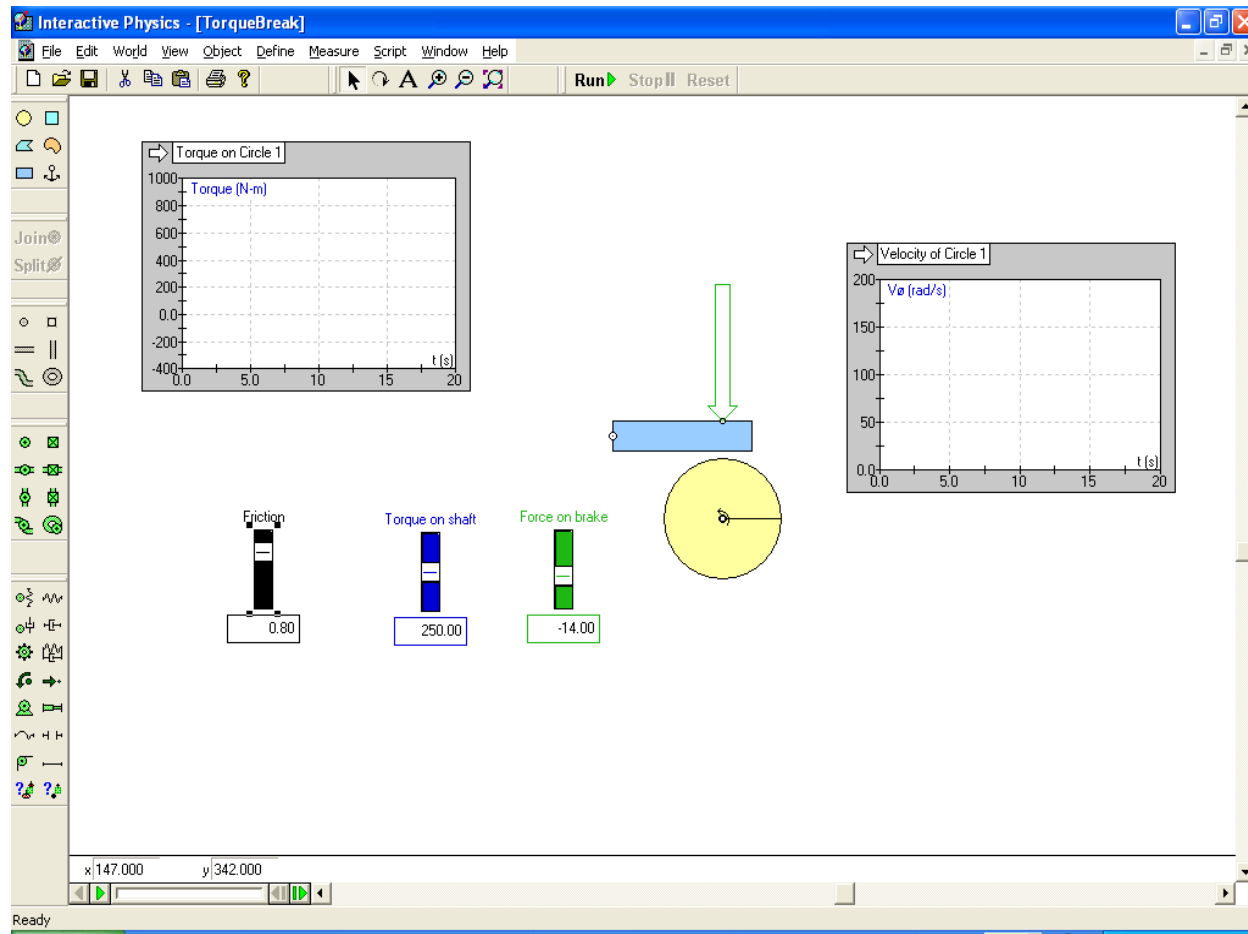
# Learn about Work

- Students apply force to a mass to produce work.
- Adjust the mass, kinetic friction and the force to see the effects on the work done.
- “Play with the simulation”
- One student maximized friction and force, and minimized mass. The cube started rotating and bounced off the track. Teachable moment about what happened.

# Torque and friction

- Torque is a force in a rotating direction.
- I brought in a torque wrench to show how torque could be measured.
- We spoke about an electric pencil sharpener. The rotating force produces work, resulting in a sharpened pencil.
- Too little load, fast spinning motor, no work.
- Too much load, stopped sharpener motor, no work.
- Measure rotational force in foot-pounds or Newton-meters

# Interactive Physics Simulation of Torque Break



# Calculation of Horsepower



A chalkboard with a table of torque and RPM values. The table has columns for Torque (N-m), Torque (ft-lb), RPMs, Torque (ft-lb), and Horsepower. The values are as follows:

Torque (N-m)	Torque (ft-lb)	RPMs	Torque (ft-lb)	Horsepower
51	744.5	0	0	0
44	642	50	32,117	6.11
		100		
		150		
		200		
		250		
		300		
		350		
		400		

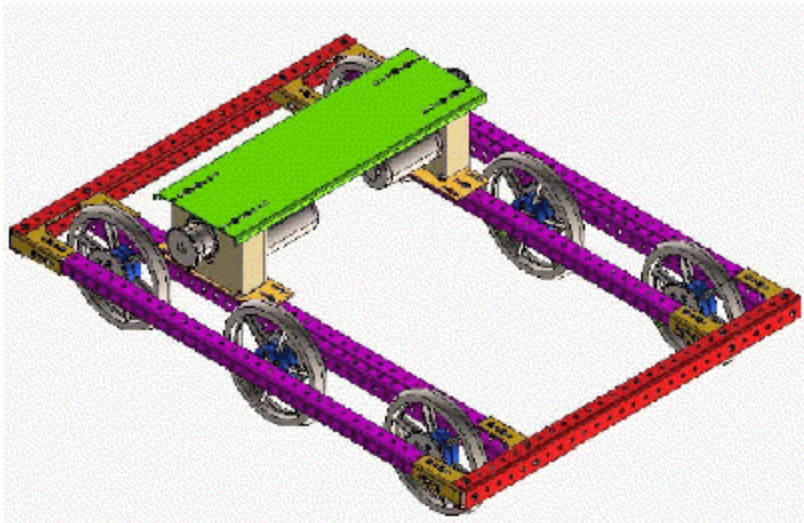
The chalkboard also has several papers pinned to it, including a yellow one and a pink one.



# A Horsepower measures the speed of work done.

- 1 horsepower = 33,000 foot-lbs. per minute
- Our chart shows RPMs vs Torque (Newton-meter)
- Convert N-m to ft.-lbs. by multiplying 0.738
- $H.P. = \text{Torque} \times \text{RPM} / 5252$
- What is the horsepower of one of the transmissions on our competitive robot?

# Our robot transmission config.



2 WHEEL DRIVE - DUAL MOTOR  
TRANSMISSION KIT STANDARD

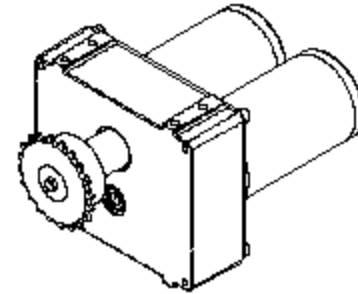
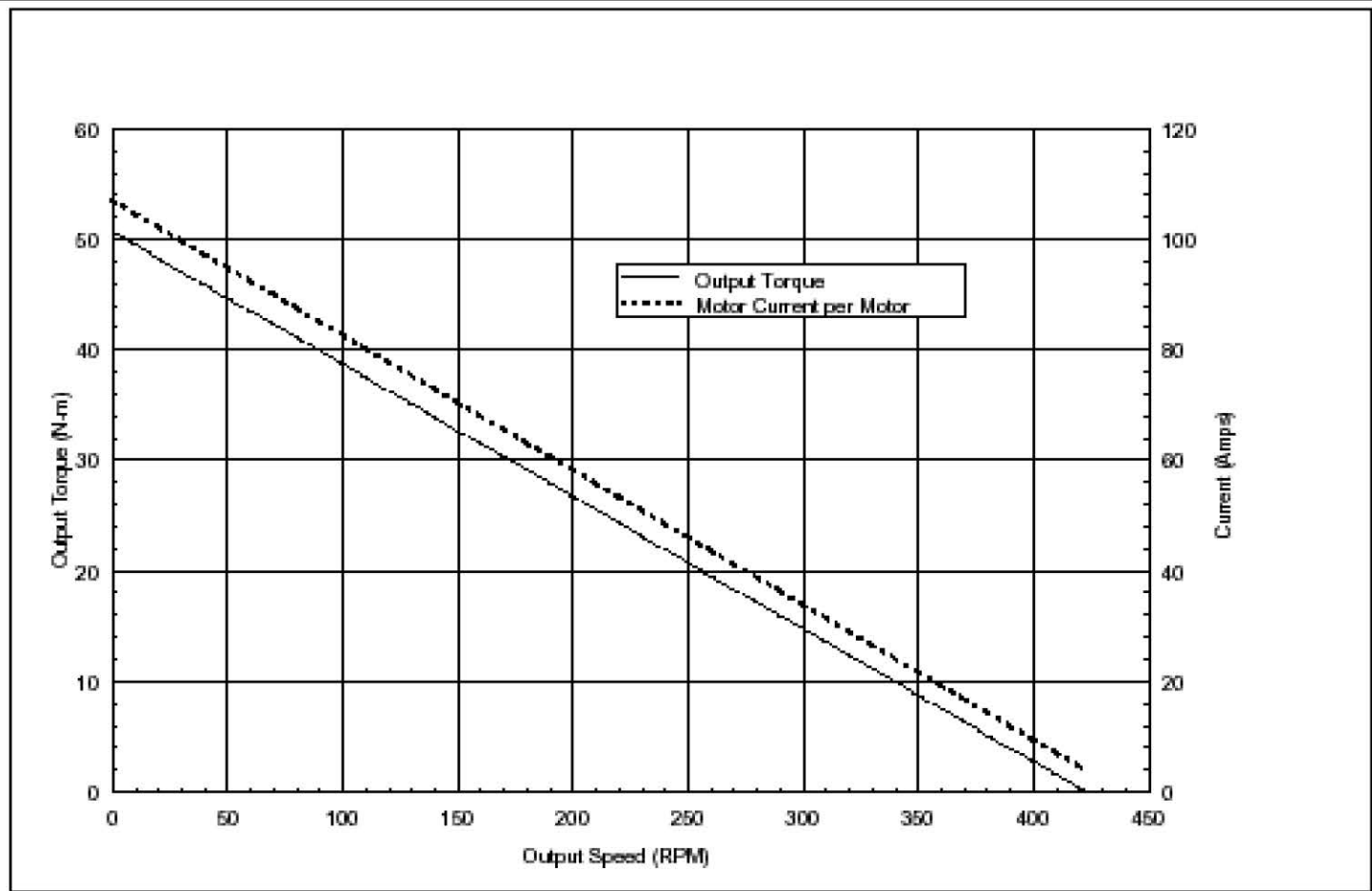


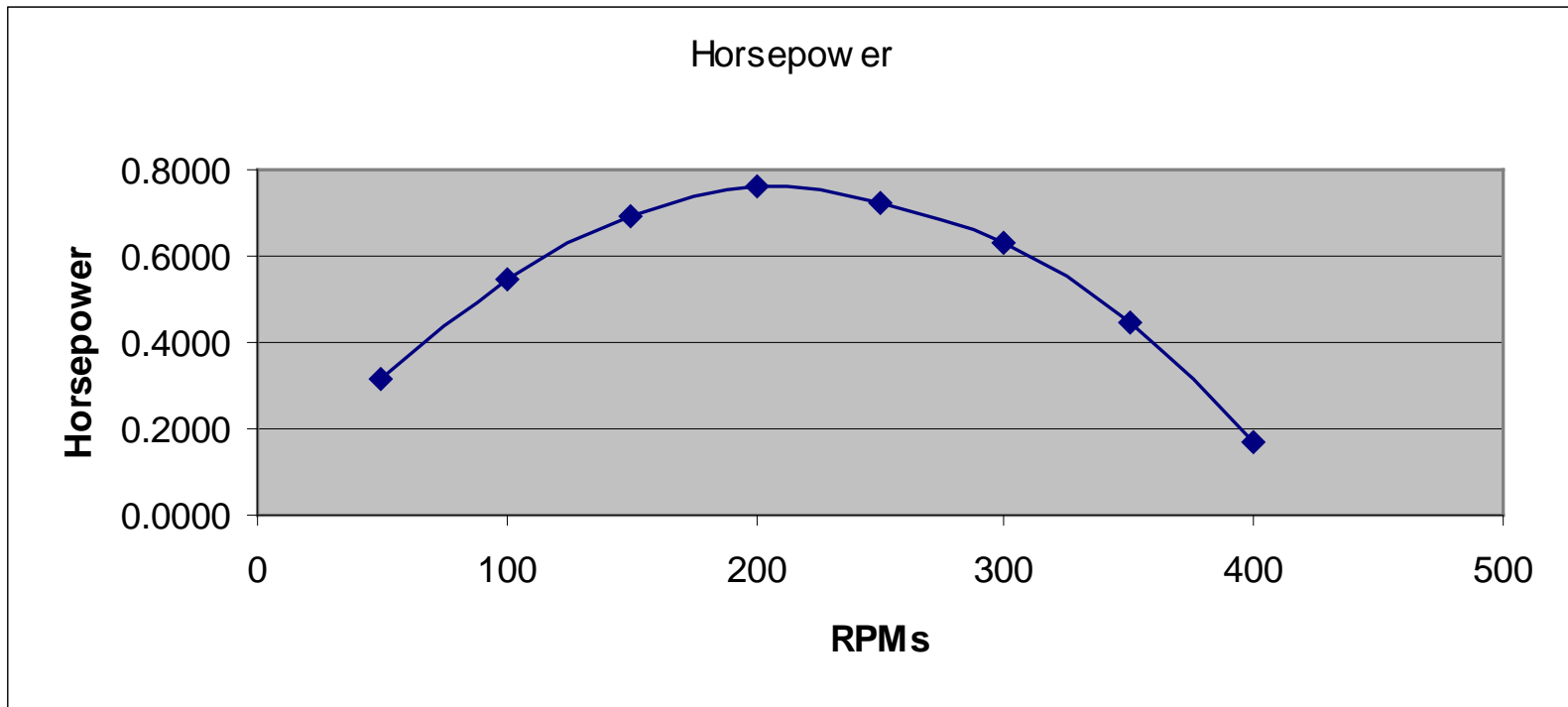
Figure 6-2. 2005 Dual Motor Transmission Kit Performance Curve



# Calculation of Power Curve

Torque (N-m)	Torque (ft.-lbs.)	RPMs	Horsepower
45	33.21	50	0.3162
39	28.782	100	0.5480
33	24.354	150	0.6956
27	19.926	200	0.7588
20.5	15.129	250	0.7202
15	11.07	300	0.6323
9	6.642	350	0.4426
3	2.214	400	0.1686

# Graph of Power Curve



# What is horsepower?

- Horsepower is different based on the speeds of a motor.
- Horsepower tells you how much work can be done in a certain time.
- The maximum horsepower for an electric motor seems to be in the middle RPMs.
- Analogy with electric pencil sharpener, what speed accomplishes the most work?
- Application with robot, program RPM limiters to maximize power output.

# References

- Auto Math Handbook, HPBooks 1991 by John Lawlor
- HowStuffWorks website,  
<http://auto.howstuffworks.com/>