Physics Experiment Manual

CA-6787

for the

PASCO

Comprehensive Physics Systems

Equipment List by Activity

Italicized type indicates items not available from *PASCO*. NOTE: Some activities also require protective gear for each student (e.g., safety goggles).

A Note About Interfaces

As mentioned in the introduction, PASCO offers two families of interfaces and sensors: *ScienceWorkshop* and PASPORT. The Comprehensive Physics Starter Systems include the *ScienceWorkshop* 750 Interface (available for either SCSI or USB) and *ScienceWorkshop* ("CI-") sensors. However, in almost all of the activities, a PASPORT Interface can be substituted for the *ScienceWorkshop* Interface, and a PASPORT sensor can be used instead of the *ScienceWorkshop* sensor. In addition, PASCO now offers an Analog Adapter (PS-2158) that allows you to connect analog *ScienceWorkshop* sensors (such as the CI-6746 Economy Force Sensor) to a PASPORT Interface. The Digital Adapter (PS-2159) allows you to connect a digital *ScienceWorkshop* sensor (such as the CI-6742 Motion Sensor) to a PASPORT Interface. (NOTE: PASPORT sensors cannot be connected to *ScienceWorkshop* interfaces.)

A Note About Equipment

In some cases, an item in the equipment list may have a different number than what is included in the Comprehensive Physics Systems. For example, the equipment list might show "ME-6800 Projectile Launcher", but the Comprehensive Physics Starter System includes the "ME-6825 Mini Launcher". The items in the Comprehensive Physics Systems are equivalent to items in the equipment list.

Act	Title	Equipment List	Qty	Cat. #
01	**Period of a Pendulum** Use a Motion Sensor to measure the motion of a pendulum as it swings back and forth.	PASCO Interface (for one sensor) Motion Sensor Photogate Pendulum Set Pendulum Clamp Large Rod Base Rod, 120-cm String Meter Stick Balance *Protractor*	1 1 1 1 1 1 1 m 1 1 1	CI-7500 CI-6870 CI-6742 ME-8752 SE-9443 ME-8735 ME-8738 SE-8050 SE-8695 SE-8723
02	**Circumference versus Diameter** Use *DataStudio* to record and display data.	*DataStudio* Software	1	CI-6870
03	**Relative Motion: Frame of Reference** Use the Motion Sensor to measure the motion of carts as they move relative to each other.	PASCO Interface (for one sensor) Motion Sensor Cart Adapter Accessory 1.2 m Dynamics Track Dynamics Cart Collision Cart *Card (about 10 cm by 10 cm)*	1 1 1 1 1 1 1	CI-7500 CI-6742 ME-6743 ME-9435A ME-9430 ME-9454
04A	**Position and Time – Match Graph** Use a Motion Sensor to measure the motion of a student relative to the sensor.	PASCO Interface (for one sensor) Motion Sensor *Reflector Board (optional)*	1 1 1	CI-7500 CI-6742 648-07373

04B	**Velocity and Time – Match Graph** Use a Motion Sensor to measure the motion of a student relative to the sensor.	PASCO Interface (for one sensor) Motion Sensor *Reflector Board (optional)*	1 1 1	CI-7500 CI-6742 648-07373
05	**Instantaneous Speed versus Average Speed** Use Photogates to time the motion of a cart.	PASCO Interface (for two sensors) IDS Photogates and Fences 1.2 m Dynamics Track Dynamics Cart Meter Stick	1 1 1 1 1	CI-7500 ME-9471A ME-9435A ME-9430 SE-8695
06	**Velocity of a Motorized Cart** Use a Motion Sensor to measure the motion of a motorized cart for different speeds of the cart.	PASCO Interface (for one sensor) Motion Sensor 1.2 m Dynamics Track Motorized Cart	1 1 1 1	CI-7500 CI-6742 ME-9435A ME-9781
07	**Constant Velocity and Constant Acceleration** Use Motion Sensors to measure the motion of a motorized cart and a fan cart.	PASCO Interface (for two sensors) Motion Sensor 1.2 m Dynamics Track Motorized Cart Dynamics Cart Fan Accessory Time Pulse Accessory	1 2 2 1 1 1 2	CI-7500 CI-6742 ME-9435A ME-9781 ME-9430 ME-9491 ME-9496
08	**Constant Acceleration: Graph P, V, and A for a Fan Cart** Use a Motion Sensor to measure the motion of a fan cart.	PASCO Interface (one sensor) Motion Sensor 1.2 m Dynamics Track Dynamics Cart Fan Accessory	1 1 1 1 1	CI-7500 CI-6742 ME-9435A ME-9430 ME-9491
09	**Constant Acceleration: Graph P, V, and A for a Cart Up and Down an Incline** Use an Acceleration Sensor and a Motion Sensor to measure the motion of a cart as it goes up and back down on an inclined track.	PASCO Interface (for two sensors) Acceleration Sensor Motion Sensor 1.2 m Dynamics Track Dynamics Cart *Block or book*	1 1 1 1 1 1	CI-7500 CI-6558 CI-6742 ME-9435A ME-9430
10	**Does Acceleration = g sin θ?** Use an Acceleration Sensor to measure the acceleration of a cart moving down an inclined track.	PASCO Interface (for one sensor) Acceleration Sensor 1.2 m Dynamics Track Dynamics Cart Large Rod Base Rod, 45-cm	1 1 1 1 1 1	CI-7500 CI-6558 ME-9435A ME-9430 ME-8735 ME-8736
11	**Acceleration of a Freely Falling Ball** Use a Motion Sensor to measure the motion of a falling ball.	PASCO Interface (for one sensor) Motion Sensor Large Rod Base Rod, 45-cm Meter Stick *Ball, rubber*	1 1 1 1 1 1	CI-7500 CI-6742 ME-8735 ME-8736 SE-8695
12	**Acceleration of a Freely Falling Picket Fence** Use a Photogate to measure the motion of a falling picket fence.	PASCO Interface (for one sensor) Photogate/Pulley System (ME-6838) Picket Fence Universal Table Clamp	1 1 1 1	CI-7500 ME-9471A ME-9377A ME-9376B

13A	**Projectile Motion – Change Initial Speed** Use Photogates and a Time-of-Flight Accessory to measure the initial speed and flight time of a projectile	PASCO Interface (for three sensors) Photogate Head (ME-9498) Time-of-Flight Accessory Photogate Mounting Bracket Projectile Launcher Metric Measuring Tape, 30 m Extension Cord, 6 m C-clamp, Large	1 2 1 1 1 1 1 1	CI-7500 ME-9471A ME-6810 ME-6821 ME-6800 SE-8712 PI-8117 SE-7285
13B	**Projectile Motion – Change Initial Speed** Use Photogates and Time-of-Flight Accessory to measure the initial speed and flight time of a projectile	PASCO Interface (for three sensors) Photogate Head (ME-9498) Time-of-Flight Accessory Photogate Mounting Bracket Projectile Launcher Metric Measuring Tape, 30 m Extension Cord, 6 m C-clamp, Large	1 2 1 1 1 1 1 1	CI-7500 ME-9471A ME-6810 ME-6821 ME-6800 SE-8712 PI-8117 SE-7285
14	**Newton's First Law – No Net Force** Use a Motion Sensor to measure the motion of a cart as it experiences different applied force.	PASCO Interface (for one sensor) Motion Sensor 1.2 m Dynamics Track Dynamics Cart Fan Accessory Friction Block (ME-9807)	1 1 1 1 1 1	CI-7500 CI-6742 ME-9435A ME-9430 ME-9491 ME-9435A
15A	**Newton's Second Law - Constant Mass, Changing Force** Use a Motion Sensor to measure the motion of a cart accelerated by a net force.	PASCO Interface (for one sensor) Motion Sensor 1.2 m Dynamics Track Dynamics Cart Mass and Hanger Set Super Pulley with Clamp (ME-9448A) Balance String	1 1 1 1 1 1 1 1 m	CI-7500 CI-6742 ME-9435A ME-9430 ME-8967 ME-9435A SE-8723 SE-8050
15B	**Newton's Second Law – Changing Mass, Constant Force** Use a Motion Sensor to measure the motion of a cart accelerated by a net force.	PASCO Interface (for one sensor) Motion Sensor 1.2 m Dynamics Track Dynamics Cart Mass and Hanger Set Super Pulley with Clamp (ME-9448A) Balance String	1 1 1 1 1 1 1 1 m	CI-7500 CI-6742 ME-9435A ME-9430 ME-9348 ME-9435A SE-8723 SE-8050
16	**Newton's Second Law – Push-Pull a Cart** Use a Motion Sensor to measure the motion of a cart and use a Force Sensor to measure the amount of force applied.	PASCO Interface (for two sensors) Motion Sensor Force Sensor 1.2 m Dynamics Track Dynamics Cart Balance	1 1 1 1 1 1	CI-7500 CI-6742 CI-6746 ME-9435A ME-9430 SE-8723
17	**Newton's Third Law – Tug-of-War** Use Force Sensors to measure the force each exerts during a tug-of-war between the sensors.	PASCO Interface (for two sensors) Force Sensor String	1 2 1 m	CI-7500 CI-6746 SE-8050
18	**Newton's Second Law – Atwood's Machine** Use the Photogate/Pulley System to measure the motion of two masses strung over a pulley as one moves up and the other down.	PASCO Interface (for one sensor) Photogate/Pulley System (ME-6838) Mass and Hanger Set Universal Table Clamp String	1 1 1 1 1 m	CI-7500 ME-9471A ME-9348 ME-9376B SE-8050

19	**Archimedes' Principle - Buoyant Force** Use a Force Sensor to measure the force on an object as it is lowered into water.	PASCO Interface (for one sensor)	1	CI-7500
		Force Sensor	1	CI-6746
		Large Rod Base	1	ME-8735
		Rod, 45-cm	2	ME-8736
		Lab Jack, Medium	1	SE-9373
		Double Rod Clamp	1	ME-9873
		Density Set	1	ME-8569
		Calipers	1	SF-8711
		String	1 m	SE-8050
		Beaker, 1000 mL	1	SE-7288
		Water	0.8 L	
20	**Coefficients of Static and Sliding Friction** Use a Force Sensor to measure the force on an object as it is pulled at constant speed across a surface.	PASCO Interface (for one sensor)	1	CI-7500
		Force Sensor	1	CI-6746
		1.2 m Dynamics Track	1	ME-9435A
		Discover Friction Accessory	1	ME-9574
		Mass Bar	2	ME-9435A
		Balance	1	SE-8723
		String	1 m	SE-8050
21	**Factors that Determine Sliding (Kinetic) Friction** Use a Photogate/Pulley System to measure the motion of a friction block.	PASCO Interface (for one sensor)	1	CI-7500
		Photogate/Pulley System (ME-6838)	1	ME-9471A
		Friction Block (ME-9807)	1	ME-9435A
		Mass and Hanger Set	1	ME-9348
		Universal Table Clamp	1	ME-9376B
		Balance	1	SE-8723
		String	1 m	SE-8050
22A	**Terminal Velocity for Objects of Different Surface Area and Constant Mass** Use a Motion Sensor to measure the motion of falling objects that have the same mass but different surface area.	PASCO Interface (for one sensor)	1	CI-7500
		Motion Sensor	1	CI-6742
		Paper shapes to be dropped	3	
22A	**Terminal Velocity for Objects of Constant Surface Area and Different Mass** Use a Motion Sensor to measure the motion of falling objects that have the same surface area but different mass.	PASCO Interface (for one sensor)	1	CI-7500
		Motion Sensor	1	CI-6742
		Coffee filter	12	
23A	**Conservation of Momentum in an Inelastic Collision** Use two Motion Sensors to measure the motion of two carts before and after an inelastic collision.	PASCO Interface (for two sensors)	1	CI-7500
		Motion Sensor	2	CI-6742
		1.2 m Dynamics Track	1	ME-9435A
		Dynamics Cart	2	ME-9430
		Balance	1	SE-8723
23B	**Conservation of Momentum in an Elastic Collision** Use two Motion Sensors to measure the motion of two carts before and after an elastic collision.	PASCO Interface (for two sensors)	1	CI-7500
		Motion Sensor	2	CI-6742
		1.2 m Dynamics Track	1	ME-9435A
		Dynamics Cart	2	ME-9430
		Balance	1	SE-8723

24	**Impulse and Change in Momentum** Use a Motion Sensor to measure the motion of a cart as it collides with a magnetic bumper. Use a Force Sensor to measure the force of the collision.	PASCO Interface (for two sensors)	1	CI-7500
		Motion Sensor	1	CI-6742
		Force Sensor	1	CI-6746
		1.2 m Dynamics Track	1	ME-9435A
		IDS Adjustable Feet	1	ME-9470
		Dynamics Cart	1	ME-9430
		Accessory Bracket with Bumpers	1	CI-6545
		Balance	1	SE-8723
		Heavy object (e.g., book)	1	
25	**Conservation of Energy for a Falling Ball** Use a Motion Sensor to measure the motion of a ball as it falls away from the sensor.	PASCO Interface (for one sensor)	1	CI-7500
		Motion Sensor	1	CI-6742
		Large Rod Base	1	ME-8735
		Rod, 45-cm	2	ME-8736
		Double Rod Clamp	1	ME-9873
		Softball or basketball	1	
26	**Discover Gravitational Potential Energy** Use a Motion Sensor to measure the motion of a ball as it is moved up and down relative to the sensor.	PASCO Interface (for one sensor)	1	CI-7500
		Motion Sensor	1	CI-6742
		Softball or similar ball	1	
27	**Hooke's Law – Stretch a Spring** Use a Force Sensor to measure the force applied to a spring. Use a Rotary Motion Sensor to measure the amount of stretch.	PASCO Interface (for two sensors)	1	CI-7500v
		Force Sensor	1	CI-6746
		Motion Sensor	1	CI-6742
		Large Rod Base	1	ME-8735
		Rod, 120-cm	1	ME-8741
		Rod, 45-cm	1	ME-8736
		Double Rod Clamp	1	ME-9873
		Spring (ME-9803)	1	ME-9435A
		Linear Motion Accessory (CI-6688)	1	OS-8535
28	**Measure the Elastic Potential Energy of a Spring** Use a Force Sensor to measure the force applied to a spring. Use a Rotary Motion Sensor to measure the amount of stretch.	PASCO Interface (for two sensors)	1	CI-7500
		Force Sensor	1	CI-6746
		Motion Sensor	1	CI-6742
		Large Rod Base	1	ME-8735
		Rod, 120-cm	1	ME-8741
		Rod, 45-cm	1	ME-8736
		Double Rod Clamp	1	SE-9873
		Spring (ME-9803)	1	ME-9435A
		Linear Motion Accessory (CI-6688)	1	OS-8535
29	**Transform Gravitational Potential Energy to Kinetic Energy** Use a Rotary Motion Sensor to measure the motion of a descending mass and a rotating disk.	PASCO Interface (for one sensor)	1	CI-7500
		Rotary Motion Sensor	1	CI-6538
		Large Rod Base	1	ME-8735
		Rod, 45-cm	1	ME-8736
		Rotational Accessory	1	CI-6691
		Balance	1	SE-8723
		Mass and Hanger Set	1	ME-9348
		Thread	1 m	

30	**Transform Gravitational Potential Energy to Electric Energy** Use a Voltage Sensor to measure the voltage across a resistor of known value as the generator produces electric energy.	PASCO Interface (for one sensor)	1	CI-7500
		Voltage Sensor	1	CI-6503
		Energy Transfer – Generator	1	ET-8771
		Large Rod Base	1	ME-8735
		Rod, 90-cm	1	ME-8738
		No-Bounce Pad	1	SE-7347
		Mass and Hanger Set	1	ME-9348
		Meter Stick	1	SE-8695
		Thread	1 m	
31	**Conservation of Energy for a Simple Pendulum** Use a Rotary Motion Sensor to measure the motion of a simple physical pendulum.	PASCO Interface (for one sensor)	1	CI-7500
		Rotary Motion Sensor	1	CI-6538
		Rotational Accessory	1	CI-6691
		Large Rod Base	1	ME-8735
		Rod, 45-cm	1	ME-8736
		Balance	1	SE-8723
		Meter Stick	1	SE-8695
32	**Work-Energy Theorem: Compare W to ΔE** Use a Force Sensor to measure the force applied to a cart. Use the Photogate/Pulley System to measure the motion of the cart.	PASCO Interface (for two sensors)	1	CI-7500
		Force Sensor	1	CI-6746
		Photogate/Pulley System (ME-6838)	1	ME-9471A
		1.2 m Dynamics Track	1	ME-9435A
		Dynamics Cart	1	ME-9430
		Mass and Hanger Set	1	ME-9348
		Universal Table Clamp	1	ME-9376B
		Balance	1	SE-8723
		String	1.2 m	SE-8050
33	**Conservation of Momentum and Kinetic Energy in Collisions** Use two Rotary Motion Sensors to measure the motion of carts in elastic and inelastic collisions.	PASCO Interface (for two sensors)	1	CI-7500
		Rotary Motion Sensor	2	CI-6538
		Dynamics Track Mount	2	CI-6692
		RMS/IDS Adapter	2	ME-6569
		Dynamics Cart	2	ME-9430
		1.2 m Dynamics Track	1	ME-9435A
		Balance	1	SE-8723
		Thread	5 m	
34	**Simple Harmonic Motion – Mass on a Spring** Use a Motion Sensor to measure the motion of a mass on the end of a spring.	PASCO Interface (for one sensor)	1	CI-7500
		Motion Sensor	1	CI-6742
		Large Rod Base	1	ME-8735
		Rod, 45-cm	2	ME-8736
		Hooke's Law Spring Set	1	SE-8749
		Mass and Hanger Set	1	ME-9348
		Double Rod Clamp	1	ME-9873
		Balance	1	SE-8723
35	**Driven Harmonic Motion – Mass on a Spring** Use a Power Amplifier to power a wave driver. Use a Motion Sensor to measure the motion of a mass on a spring.	PASCO 750 Interface	1	CI-7500
		Motion Sensor	1	CI-6742
		Power Amplifier	1	CI-6552A
		Large Rod Base	1	ME-8735
		Rod, 45-cm	1	ME-8736
		Spring (ME-9803)	1	ME-9435A
		Mass and Hanger Set	1	ME-9348
		String Vibrator	1	WA-9857
		Balance	1	SE-8723
		Banana Plug Patch Cord	2	SE-9750

36	**Simple Harmonic Oscillation** Use a Photogate to measure the motion of an oscillating cart.	PASCO Interface (for one sensor)	1	CI-7500
		Photogate/Pulley System (ME-6838)	1	ME-9471A
		IDS Photogate Bracket (ME-9806)	1	ME-9471A
		Spring (ME-9803)	2	ME-9435A
		1.2 m Dynamics Track	1	ME-9435A
		Dynamics Cart	1	ME-9430
		Five-pattern Picket Fence (ME-9804)	1	ME-9471A
		Balance	1	SE-8723
37	**Period of a Large Amplitude Pendulum** Use a Rotary Motion Sensor to measure the motion of a large amplitude pendulum.	PASCO Interface (for one sensor)	1	CI-7500
		Rotary Motion Sensor	1	CI-6538
		Large Rod Base	1	ME-8735
		Rod, 45-cm	1	ME-8736
		Rotational Accessory	1	CI-6691
38	**Centripetal Force on a Pendulum** Use a Rotary Motion Sensor to measure the angular velocity of a pendulum. Use a Force Sensor to measure the centripetal force.	PASCO Interface (for two sensors)	1	CI-7500
		Force Sensor	1	CI-6746
		Rotary Motion Sensor	1	CI-6538
		Rod, 45-cm	1	ME-8736
		Universal Table Clamp	1	ME-9376B
		Centripetal Force Pendulum	1	ME-9821
39	**Rotational Motion: Plot Angular Position and Angular Velocity** Use a Rotary Motion Sensor to measure the rotation of a disk that has a constant angular acceleration.	PASCO Interface (for one sensor)	1	CI-7500
		Rotary Motion Sensor	1	CI-6538
		Rotational Accessory	1	CI-6691
		Large Rod Base	1	ME-8735
		Rod, 45-cm	1	ME-8736
		Mass and Hanger Set	1	ME-9348
		Thread	1 m	
40	**Rotational Inertia of Different Objects** Use a Rotary Motion Sensor to measure the rotation of a disk and a ring.	PASCO Interface (for one sensor)	1	CI-7500
		Rotary Motion Sensor	1	CI-6538
		Rotational Accessory	1	CI-6691
		Large Rod Base	1	ME-8735
		Rod, 45-cm	1	ME-8736
		Mass and Hanger Set	1	ME-9348
		Calipers	1	SF-8711
		Thread	1 m	
41	**Heat and Temperature** Use a Temperature Sensor to measure the temperature of two different amounts of water as they are heated.	PASCO Interface (for one sensor)	1	CI-7500
		Temperature Sensor	1	CI-6605
		Power Amplifier	1	CI-6552A
		Heating Resistor	1	CI-6514A
		Graduated cylinder, 100 mL	1	SE-7289
		Foam cup with lid	1	
		Water	0.3 L	
42	**Transfer of Energy by Radiation** Use two Temperature Sensors to measure the change of temperature for water in two similar cans that have different surfaces.	PASCO Interface (for two sensors)	1	CI-7500
		Temperature Sensor	2	CI-6605
		Thermal Radiation Cans	1	CI-6514A
		Graduated cylinder, 100 mL	1	SE-7289
		Thermal insulation pad	2	
		Tongs	1 pair	
		Water, hot (90˚C)	0.8 L	

43	**Specific Heat** Use a Temperature Sensor to measure the change in temperature of water when a metal object of a different temperature is put into the water.	PASCO Interface (for one sensor) Temperature Sensor Mass and Hanger Set Balance Graduated cylinder, 100 mL String *Foam cup with lid* *Beaker* *Water* *Ice*	1 1 1 1 1 20 cm 1 1 0.3 L 0.1 L	CI-7500 CI-6605 ME-9348 SE-8723 SE-7289 SE-8050
44	**Electrical Equivalent of Heat** Use a Temperature Sensor to measure the change in temperature of water that is heated by a resistor. Use a Power Amplifier to power the resistor.	PASCO 750 Interface Temperature Sensor Power Amplifier Heat Resistor, 10 Ω, 1 W Balance *Foam cup with lid* *Water*	1 1 1 1 1 1 0.2 L	CI-7500 CI-6605 CI-6552A CI-6514A SE-8723
45	**Boyle's Law: Pressure and Volume of a Gas at Constant Temperature** Use a Pressure Sensor to measure the change in pressure of a gas as its volume is changed.	PASCO Interface (for one sensor) Pressure Sensor – Absolute Coupling, quick-release Syringe Tubing *Glycerin*	1 1 1 1 1 1 mL	CI-7500 CI-6532A
46	**Pressure and Temperature of a Gas** Use a Pressure Sensor and a Temperature Sensor to measure the pressure of a gas inside a container and the temperature of the water outside the container.	PASCO Interface (for two sensors) Pressure Sensor – Absolute Temperature Sensor Large Rod Base Rod, 45-cm Clamp, Buret Hot Plate Beaker, 1-L *Flask, Erlenmeyer, 125-mL* *Rubber stopper, one-hole* *Tongs* *Glycerin* *Ice, crushed* *Water*	1 1 1 1 1 1 1 4 1 1 1 pair 1 mL 1 L 4L	CI-7500 CI-6532A CI-6605 ME-8735 ME-8736 SE-9446 SE-8767 SE-7288
47	**Behavior and Characteristics of Sound Waves** Use a Sound Sensor to measure sounds from various sources.	PASCO Interface (for one sensor) Sound Sensor Speaker Sound Generator, 3-Chime Tuning Fork Set (optional)	1 1 1 1 1	CI-7500 CI-6506 WA-9900 SE-9081 SF-9236
48	**Demonstration of Transverse and Longitudinal Waves** Use a double-length slinky to demonstrate wave types.	Double-length Slinky Demonstration Wave Spring	1 1	SE-8760 WA-7334
49	**General Properties of Waves** Use the Sound Creator part of the WAVEPORT software to investigate wave properties	WAVEPORT Software	1	CI-6872

50	**Standing Waves on a String** Use a Sine Wave Generator and String Vibrator to create standing waves on a string.	PASCO 750 Interface	1	CI-7500
		Power Amplifier	1	CI-6552A
		String Vibrator	1	WA-9857
		String	2 m	SE-8050
		Braided Cord, Yellow	2 m	ME-9876
		Elastic Cord	2 m	SE-9409
		Banana Plug Patch Cord	2	SE-9750
		Super Pulley (ME-9450)	1	ME-9471A
		Pulley Mounting Rod (SA-9242)	1	ME-9471A
		Universal Table Clamp	1	ME-9376B
		Mass and Hanger Set	1	ME-9348
		C-clamp, Large	1	SE-7285
		Balance	1	SE-8723
		Tape Measure	1	SE-8712
		Strobe (optional)	1	SF-9211
51	**Resonant Modes of Sound in a Tube** Use a Sine Wave Generator and Open Speaker to generate sound at one end of a resonance tube.	PASCO 750 Interface	1	CI-7500
		Power Amplifier	1	CI-6552A
		Open Speaker	1	WA-9900
		Economy Resonance Tube	1	WA-9495
		Banana Plug Patch Cord	2	SE-9750
52	**Speed of Sound in Air** Use a Sound Sensor to measure the initial pulse of sound and its echo in a tube.	PASCO Interface (for one sensor)	1	CI-7500
		Sound Sensor	1	CI-6505B
		Economy Resonance Tube	1	WA-9495
		Large Rod Base	1	ME-8735
		Rod, 45-cm	1	ME-8736
		Double Rod Clamp	1	ME-9873
		Pulley Mounting Rod (SA-9242)	1	ME-9471A
		Tape Measure	1	SE-8712
53	**Superposition of Sound Waves** Use the Sound Creator feature of the WAVEPORT Software to generate two or more sound waves.	WAVEPORT Software	1	CI-6872
54	**Interference of Sound Waves** Use the Sound Creator feature of the WAVEPORT Software to generate two or more sound waves.	WAVEPORT Software	1	CI-6872
55	**Shadow and Color in Light** Use a Light Source and a Ray Optics Kit to explore the composition of white light and the formation of a shadow.	Light Source, Basic Optics	1	OS-8517
		Ray Optics Kit, Basic Optics	1	OS-8516
		Viewing Screen, Basic Optics	1	OS-8518
		Ruler, opaque	1	
56	**Object and Image Distances for a Thin Lens** Use a Light Source, Optics Bench, Viewing Screen, and lens to confirm the thin lens formula.	Light Source, Basic Optics	1	OS-8517
		Optics Bench, Basic Optics	1	OS-8518
		Viewing Screen, Basic Optics	1	OS-8518
		100 mm Convex Lens, Basic Optics	1	OS-8518
57	**Reflection and Refraction** Use a Light Source, Ray Optics Kit, ruler, and protractor to measure angles of a light ray.	Light Source, Basic Optics	1	OS-8517
		Ray Optics Kit, Basic Optics	1	OS-8516
		White paper, sheet	2	
		Metric ruler	1	
		Protractor	1	

58	**Focal Length of a Concave Mirror** Use a Light Source, Concave Mirror and Half-Screen Accessory to measure the focal length.	Light Source, Basic Optics Concave Mirror Accessory Optics Bench, Basic Optics	1 1 1	OS-8517 OS-8532 OS-8518
59	**Optical Instruments: Telescope and Microscope** Construct a simple telescope and determine its magnification, then construct a simple microscope and determine its magnification.	Optics Bench, Basic Optics Viewing Screen, Basic Optics Convex Lens, 100 mm focal length Convex Lens, 200 mm focal length *Metric ruler*	1 1 1 1 1	OS-8518 OS-8518 OS-8518 OS-8518
60	**Variation of Light Intensity** Use a Light Sensor to measure light intensity from different light sources.	PASCO Interface (for one sensor) Light Sensor Light Source, Basic Optics *Fluorescent light source* *Incandescent light source*	1 1 1 1 1	CI-7500 CI-6504 OS-8517
61	**Light Intensity versus Distance**	PASCO Interface (for two sensors) Light Sensor Rotary Motion Sensor Optics Bench, Basic Optics Aperture Bracket Dynamics Track Mount Mass, 20-g String	1 1 1 1 1 1 1 1 m	CI-7500 CI-6504 CI-6538 OS-8518 OS-8534 CI-6692 ME-9348 SE-8050
62	**Polarization: Verify Malus' Law** Use a Light Sensor to measure light intensity through two polarizers. Use a Rotary Motion Sensor to measure the angle between the polarizers.	PASCO Interface (for two sensors) Light Sensor Rotary Motion Sensor Light Source and Bracket, Basic Optics Optics Bench, Basic Optics Aperture Bracket Polarization Analyzer	1 1 1 1 1 1 1	CI-7500 CI-6504 CI-6538 OS-8517 OS-8518 OS-8534 OS-8533
63	**Diffraction of Light** Use a Light Sensor to measure the intensity of maxima in a diffraction pattern. Use a Rotary Motion Sensor to measure the relative position of the maxima.	PASCO Interface (for two sensors) Light Sensor Rotary Motion Sensor Slit Accessories Linear Translator Aperture Bracket Diode Laser Optics Bench, Basic Optics	1 1 1 1 1 1 1 1	CI-7500 CI-6504 CI-6538 OS-8523 OS-8535 OS-8534 OS-8525 OS-8518
64	**Electrostatic Charging** Use a Charge Sensor to measure the charge and polarity of two 'charge producers'.	PASCO Interface (for one sensor) Charge Sensor Charge Producers and Proof Plane Faraday Ice Pail	1 1 1 1	CI-7500 CI-6555 ES-9057A ES-9024A
65	**Electrostatic Charge Distribution** Use a Charge Sensor to measure the distribution of charge on a conductive sphere.	PASCO Interface (for one sensor) Charge Sensor Charge Producers and Proof Plane Faraday Ice Pail Conductive Spheres (set of 2) Electrostatics Voltage Source	1 1 1 1 1 1	CI-7500 CI-6555 ES-9057A ES-9024A ES-9059B ES-9077
66	**Electric Field Around a Conductor** Use a Voltage Sensor to determine the shape of the electric field around a conductor.	PASCO Interface (for one sensor) Voltage Sensor Equipotential and Field Mapper Kit Power Supply, 15 VDC *Pencil* *Tape, sticky*	1 1 1 1 1 1 roll	CI-7500 CI-6503 PK-9023 SE-9720

67	**Ohm's Law** Use the Power Output feature of the *ScienceWorkshop* 750 Interface to power a circuit. Measure the voltage and current through different resistors.	PASCO 750 Interface AC/DC Electronics lab Banana Plug Patch Cord	1 1 2	CI-7500 EM-8656 SE-9750
68	**Voltage and Current in Simple Circuits** Use a Voltage Sensor and a Current Sensor to measure voltage and current in a simple circuit of batteries and light bulbs in series and parallel.	PASCO Interface (for two sensors) Voltage Sensor Current Sensor AC/DC Electronics Lab "D" Cell, 1.5 V	1 1 1 1 2	CI-7500 CI-6503 CI-6556 EM-8656 PI-6602
69	**Resistors in Series and Parallel Circuits** Use a Voltage Sensor and a Current Sensor to measure voltage and current for resistors in series and parallel.	PASCO Interface (for two sensors) Voltage Sensor Current Sensor AC/DC Electronics Lab "D" Cell, 1.5 V	1 1 1 1 2	CI-7500 CI-6503 CI-6556 EM-8656 PI-6602
70	**Kirchhoff's Laws: Voltage and Current in Circuits** Use a Voltage Sensor and a Current Sensor to measure voltage and current across and in parts of a complex circuit.	PASCO Interface (for two sensors) Voltage Sensor Current Sensor AC/DC Electronics Lab "D" Cell, 1.5 V Banana Plug Patch Cord	1 1 1 1 1 2	CI-7500 CI-6503 CI-6556 EM-8656 PI-6602 SE-9750
71	**Charging and Discharging the RC Circuit** Use a Voltage Sensor to measure the voltage across a capacitor as it is charged and discharged through a resistor.	PASCO 750 Interface Voltage Sensor AC/DC Electronics Lab Banana Plug Patch Cord	1 1 1 2	CI-7500 CI-6503 EM-8656 SE-9750
72	**Resonant Frequencies of the LRC Circuit** Use a Voltage Sensor to measure the voltage across a resistor in the LRC circuit as the frequency of the voltage is changed.	PASCO 750 Interface Voltage Sensor AC/DC Electronics Lab Banana Plug Patch Cord	1 1 1 2	CI-7500 CI-6503 EM-8656 SE-9750
73	**General Properties of Diodes** Use a Voltage Sensor to measure the voltage across a diode and a second sensor to measure the voltage across a resistor.	PASCO 750 Interface Voltage Sensor AC/DC Electronics Lab Banana Plug Patch Cord	1 2 1 2	CI-7500 CI-6503 EM-8656 SE-9750
74	**Build a Rectifier** Use a Voltage Sensor to measure the voltage across a diode and a second sensor to measure the voltage across a resistor.	PASCO 750 Interface Voltage Sensor AC/DC Electronics Lab Banana Plug Patch Cord	1 2 1 2	CI-7500 CI-6503 EM-8656 SE-9750
75	**Transistor Lab 1 – The NPN Transistor as a Digital Switch** Use a Voltage Sensor to measure the voltage across a resistor in series with the power supply and the collector of the transistor.	PASCO 750 Interface Voltage Sensor AC/DC Electronics Lab Power Supply 5 VDC Banana Plug Patch Cord	1 1 1 1 4	CI-7500 CI-6503 EM-8656 SE-9720 SE-9750

76	**Transistor Lab 2 – Measure the Current Gain** Use a Voltage Sensor to measure the voltage across a resistor in series with the base of the transistor. Use another sensor to measure the voltage across a resistor in series with the emitter.	PASCO 750 Interface Voltage Sensor AC/DC Electronics Lab Power Supply 5 VDC Banana Plug Patch Cord	1 2 1 1 4	CI-7500 CI-6503 EM-8656 SE-9720 SE-9750
77	**Earth's Magnetic Field** Use a Magnetic Field Sensor mounted on a Rotary Motion Sensor to measure the directional variation in the Earth's field.	PASCO Interface (for two sensors) Magnetic Field Sensor Rotary Motion Sensor Zero Gauss Chamber Dip Needle Adjustable Angle Clamp Angle Indicator (ME-9495) Universal Table Clamp Rod, 45-cm	1 1 1 1 1 1 1 1 1	CI-7500 CI-6520A CI-6538 EM-8652 SF-8619 ME-8744 ME-9435A ME-9376B ME-8736
78	**Magnetic Field of a Permanent Magnet** Use a Magnetic Field Sensor and a Rotary Motion Sensor to measure the field strength of a small magnet as the distance from the magnet increases.	PASCO Interface (for two sensors) Magnetic Field Sensor Rotary Motion Sensor Linear Motion Accessory (CI-6688) Double Rod Clamp Pulley Mounting Rod (SA-9242) Large Rod Base Rod, 45-cm *Magnet, disk, neodymium, 0.125" dia.* *Tape, sticky (about 3 – 4 cm)*	1 1 1 1 1 1 2 2 1 1 roll	CI-7500 CI-6520A CI-6538 OS-8535 ME-9873 ME-9471A ME-8735 ME-8736
79	**Induction – Magnet Through a Coil** Use a Voltage Sensor to measure the induced emf in a coil as a magnet moves through the coil.	PASCO Interface (for one sensor) Voltage Sensor AC/DC Electronics Lab Bar Magnet, Alnico No-Bounce Pad	1 1 1 1 1	CI-7500 CI-6503 EM-8656 EM-8620 SE-7347
80	**Magnetic Field in a Current-Carrying Coil** Use a Power Amplifier to create and measure the current in a coil and use a Magnetic Field Sensor to measure the magnetic field strength in the coil.	PASCO 750 Interface Magnetic Field Sensor Power Amplifier Double Rod Clamp Large Rod Base Rod, 45-cm Banana Plug Patch Cord Alligator Clip Adapter Pulley Mounting Rod (SA-9242) *Magnet Wire* *Sandpaper, fine grit (sheet)* *Tape, sticky*	1 1 1 1 1 1 2 2 1 1 m 1 1 roll	CI-7500 CI-6520A CI-6552A ME-9873 ME-8735 ME-8736 SE-9750 SE-9756 ME-9471A

Equipment List by Item

This list shows each item needed for the activities and where the item is used. An asterisk (*) indicates items available from *PASCO* but not included. *Italicized* type indicates items not available from *PASCO*. NOTE: Some activities also require protective gear for each student (e.g., safety goggles, gloves, apron or lab coat).

In some cases, an item in the equipment list may have a different number than what is included in the Comprehensive Physics Systems. For example, the equipment list shows "ME-6800 Projectile Launcher", but the Comprehensive Physics Starter System includes the "ME-6825 Mini Launcher". The items in the Comprehensive Physics Systems are equivalent to items in the equipment list. In other cases, the item listed is included with another item. For example, the SA-9242 Pulley Mounting Rod and ME-9450 Super Pulley are included with the ME-9471A IDS Photogates and Fences. See the end of this list for more information.

Part No.	Software & Interface	Qty	Where Used
CI-6870F	*DataStudio* Single User License	1	All except 48,55,56,57,58,59
CI-6872C	WAVEPORT Single User License	1	49,53,54
CI-7500	*ScienceWorkshop* 750 Interface	1	All except 2,48,49,53,54,55,56,57,58,59

Part No.	Sensors & Equipment	Qty	Where Used
CI-6503	Voltage Sensor	2	30,66,68,69,70,71,72,73,74,75,76,79
CI-6504A	Light Sensor	1	60,61,62,63
CI-6506B	Sound Sensor	1	47,52
CI-6514A	Thermodynamics Kit	1	41,42,44
CI-6520A	Magnetic Field Sensor	1	77,78,80
CI-6532A	Pressure Sensor – Absolute	1	45,46
CI-6538	Rotary Motion Sensor	1	27,28,29,31,33,37,38,39,40,61,62,63,77,78
CI-6545	Accessory Bracket with Bumpers	1	24
CI-6552A	Power Amplifier II	1	35,41,44,50,51,80
CI-6555	Charge Sensor	1	64,65
CI-6556	Current Sensor	1	68,69,70
CI-6558	Acceleration Sensor	1	9,10
CI-6605	Temperature Sensor	2	41,42,43,44,46
CI-6691	Mini-Rotational Accessory	1	27,28,29,31,37,39,40
CI-6692	IDS Mount Accessory	2	33,61
CI-6742	Motion Sensor II	2	1,3,4,5,7,8,9,11,14,15A,15B,16,22A,22B,23A,23B,24,25,26,34,35
CI-6746	Economy Force Sensor	2	16,17,19,20,24,27,28,32,38
EM-8620	Bar Magnets, Alnico (set of 2)	1	79
EM-8652*	Zero Gauss Chamber	1	77
EM-8656	AC/DC Electronics Lab	1	67,68,69,70,71,72,73,74,75,76,79
ES-9042A	Faraday Ice Pail	1	64,65
ES-9057B	Charger Producers, Proof Plane	1	64,65
ES-9059B	Conductive Spheres (set of 2)	1	65
ES-9077	Electrostatics Voltage Source	1	65
ET-8771	Energy Transfer – Generator	1	30

ME-6743	Cart Adapter Accessory	1	3
ME-6569	RMS/IDS Adapter	2	33
ME-6810	Time-of-Flight Accessory	1	13A,13B
ME-6821	Photogate Mounting Bracket	1	13A,13B
ME-6825	Mini Launcher	1	13A,13B
ME-8569	Density Set	1	19
ME-8574	Discover Friction Accessory	1	20
ME-8735	Large Rod Base	1	1,10,11,19,25,27,28,29,30,31,34,35, 37,39,40,46,52,78,80
ME-8736	Steel Rod, 45-cm	1	10,11,19,25,27,28,29,31,34,35,37,38, 39,40,46,52,77,78,80
ME-8738	Steel Rod, 90-cm	2	1,27,28,30
ME-8744*	Adjustable Angle Clamp	1	77
ME-8752	Photogate Pendulum Set	1	1
ME-9348	PASCO Mass and Hanger Set	1	15A,15B,18,29,32,35,39,40,43,50,61
ME-9376B	Universal Table Clamp	1	12,18,21,32,38,50,77
ME-9377A	Picket Fence	1	12
ME-9430	Plunger Cart with Mass	1	3,6,8,9,10,14,15A,15B,16,23A,23B,24 32,33,36
ME-9435A	1.2 m Dynamics Track, No Carts	1	3,6,7,8,9,10,14,15A,15B,16,20,23A, 23B,24,32,33,36
ME-9454	Collision Cart with Mass	1	3,23A,23B
ME-9470*	IDS Adjustable Feet	1	24
ME-9471A	IDS Photogates & Fences	1	6,12,13A,13B,18,21,32,36,50,52,77, 78,80
ME-9472*	Large Table Clamp	1	
ME-9491	Fan Accessory (for PASCO Carts)	1	8,14
ME-9496*	Time Pulse Accessory	2	7
ME-9781	Variable Speed Motorized Cart	1	7
ME-9821	Centripetal Force Pendulum	1	38
ME-9873	Double Rod Clamp (3 pack)	1	19,25,27,28,34,52,78,80
ME-9876*	Braided Cord, Yellow	2 m	50
OS-8516A	Ray Optics, Basic Optics	1	55,57
OS-8517A	Light Source, Basic Optics	1	55,56,57,58,60,62
OS-8518	Geometric, Basic Optics	1	55,56,58,59,61,62,63
OS-8523	Slit Accessories, Basic Optics	1	63
OS-8525A	Diode Laser, Basic Optics	1	63
OS-8532	Concave Mirror Accessory, Basic Optics	1	58
OS-8533	Polarization Analyzer, Basic Optics	1	62
OS-8534	Aperture Bracket, Basic Optics	1	61,62,63
OS-8535	Linear Translator, Basic Optics	1	27,28,63,78
PS-6602*	"D"-cell, 1.5 V (4 pack)	1	68,69,70
PI-8117*	Extension Cord, 6 m	1	13A,13B
PK-9023	Field Mapper Kit	1	66
SE-7285*	"C"-Clamp, Large (6 pack)	1	13A,13B,50
SE-7288*	Beaker, 1-L (6 pack)	1	19,46
SE-7289*	Graduated Cylinder, 50-mL (12 pack)	1	41,42,43
SE-7342	Tuning Force Set	1	47

SE-7347	No-Bounce Pad	1	30,79
SE-8050	Braided Physics String, 300 m	1	1,15A,15B,17,18,19,20,21,32,43,50,61
SE-8695*	Meter Stick	1	1,6,11,31
SE-8712*	Metric Measuring Tape, 30 m	1	13A,13B,50,52
SE-8723*	Balance, Triple-beam	1	1,15A,15B,16,20,21,23A,23B,24,29,31,32,33,34,35,36,43,44,50
SE-8749	Hooke's Law Spring Set	1	34
SE-8760	Slinky, Double Length	1	48
SE-8767*	Hot Plate	1	46
SE-9081	Sound Generator, 3 Chime	1	47
SE-9373*	Lab Jack, Medium	1	19
SE-9409*	Elastic Cord	2 m	50
SE-9443	Clamp, Pendulum	1	1
SE-9446*	Clamp, Buret	1	46
SE-9720*	Power Supply	1	66,75,76
SE-9750	Banana Plug Patch Cords, Red (set of 5)	1	35,50,51,67,70,71,72,73,74,75,76,80
SE-9751	Banana Plug Patch Cords, Black (set of 5)	1	35,50,51,67,70,71,72,73,74,75,76,80
SE-9756	Alligator Clip Adapters (set of 10)	1	80
SF-8619	Dip Needle	1	77
SF-8711*	Calipers	1	19,40
SF-9211*	Stroboscope	1	50
TD-8557	Basic Calorimetry Set	1	43
WA-7334	Demonstration Wave Spring	1	48
WA-9495	Economy Resonance Tube	1	51,52
WA-9857	String Vibrator	1	35,50
WA-9900	Open Speaker	1	47,51
648-07373	Reflector Board for Motion Sensor	1	4,5

Items Not Supplied by *PASCO*

Item	Qty	Where Used
Card, about 10 cm by 10 cm	*1*	*3*
Flask, Erlenmeyer, 125-mL (or equivalent)	*1*	*46*
Foam cup with lid	*1*	*43,44*
Glycerin	*1 mL*	*45,46*
Light source, fluorescent, AC	*1*	*60*
Light source, incandescent, AC	*1*	*60*
Magnet wire	*5 m*	*80*
Musical instrument	*1*	*47*
Paper, white, sheet	*1*	*57*
Protractor	*1*	*57*
Rubber stopper, one hole	*1*	*46*
Ruler, metric, opaque	*1*	*55,57*
Sandpaper, fine grit, sheet	*1*	*80*
Tape, sticky	*1 roll*	*66,80*
Tongs	*1 pair*	*46*

Items Included in Other Part Numbers

Item	Includes
CI-6991 Mini-Rotational Accessory	Disk, ring, pendulum shaft, two 75-g mass for the pendulum, spool of nylon thread, *ME-9448A Super Pulley with Clamp*
ME-9435A 1.2 m Dynamics Track (no carts)	Track with pivot clamp and fixed end stop, *ME-9807 Friction Block*, adjustable end stop, 2-magnet bumper set, three *ME-9803 Harmonic Spring* (k ~ 3.5 N/m), *ME-9448A Super Pulley with Clamp, ME-9495 Angle Indicator*
ME-9471A IDS Photogates & Fences	Two *ME-9806 IDS Photogate Bracket*, two *ME-9498 Photogate Head,* two *ME-9804 Five-Pattern Cart Picket Fence, ME-9450 Super Pulley, SA-9242 Pulley Mounting Rod*
OS-8516A Ray Optics, Basic Optics	3-surface mirror, convex lens, concave lens, rhomboid lens, hollow lens
OS-8518 Geometric Basic Optics	Optics bench, viewing screen, 100 mm focal length convex lens, 200 mm focal length convex lens
OS-8535 Linear Translator, Basic Optics	Rack (equivalent to *CI-6688 Linear Motion Accessory* for use with the CI-6538 Rotary Motion Sensor), rack support, rack clamp