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Review of
Physics Workshop: The Science of Matter and Energy
Thames and Kosmos

This Physics Workshop by Thames and Kosmos is designed to introduce the physics of classical mechanics. It contains a manual that provides explanations of the principles of classical physics and provides engineering assistance in preparing the thirty-eight apparatuses for the thirty-seven experiments. It also contains a variety of high quality parts for use in constructing the apparatuses, which range in difficulty from a simple top to a wind power plant and a pendulum clock. The manual states that the workshop is designed for any person over the age of eight. The intent of this review is to provide comments and insights that may prove helpful in using this workshop.

I. General Comments

Although the kit contains an excellent manual for guiding the user through the workshops and experiments, I recommend an elementary physics text be consulted to provide a full discussion of the theory and examples of how to handle the equations used to predict the results of the experiments. For the young or inexperienced user, I also recommend some help from an adult to avoid frustration during construction of the apparatuses. I have found a generous amount of patience may be required to build and adjust the parts to get the expected performance. This results mainly from the insufficiently detailed description of how to construct each apparatus. A more step-by-step construction procedure would be appreciated, as well as more pictures of partially built apparatus that show the construction details. In addition, a list of parts and supplies that are needed but not included in the kit (a partial list appears below) would be helpful. A glossary of physics terms and their definitions and where they appear in the kit would also be helpful.

Physics experiments usually require precision measurements. In my opinion this set of workshops does not provide the equipment or the methods to make precise measurements. Keeping in mind that this kit only introduces basic concepts, a somewhat looser standard of precision is accepted. A clever user can however use the same techniques and improve the measurement precision to show the basic principles. As an example, the device in Workshop VI should be first calibrated using Hooke's law by applying known forces and creating a scale prior to using it for measuring unknown forces. This may be accomplished by filling a bottle with various amounts of water such that the bottle plus water weighs 1 ounce, 2 ounce, 3 ounces, etc up to, for example, 32 ounces. Then an appropriate scale may be made by placing a blank piece of paper on the Force Scale and marking it with the corresponding forces using the table:

Weight of bottle + water in ounces	Force in Newtons
1	0.278
2	0.556

3	0.834
4	1.112
5	1.390
6	1.668
7	1.946
8	2.224
9	2.502
10	2.780
11	3.058
12	3.336
13	3.614
14	3.892
15	4.170
16	4.448
24	6.672
32	8.896

Some of the experiments are also incomplete. With the same apparatus other basic physics principles may be demonstrated. For example, angular momentum and angular momentum conservation can be demonstrated with Workshop XXII .

II. Specific Comments

Page 7&8: The Earth Attracts Us – Workshop I Experiment 1: I suggest using toothpick in place of matchstick. The manual should point out that gravity accelerates the potato but it is the momentum that determines the distance the toothpick (matchstick) goes into the potato. Note that the "target spit" is the toothpick (matchstick).

Page 9: Weightless: "When astronauts go there, their space ships provide them no solid ground beneath their feet, leaving them to float in mid-air." The quoted sentence might have been written: The space ship has insufficient mass to provide a gravitational force of the magnitude of the Earth.

Page 9&10: Where Is the Center of Gravity: The term center of area is the mid-point of the paper (half the width and half the length of the paper). The center of gravity is the point determined using the method described in Experiment 2-Finding Your Center. Any added weight which is not uniformly distributed over the whole plate shifts the center of gravity away from the center of area.

Page 11: Tipping Force and Center of Gravity: The critical point of tipping occurs when the center of gravity is forced outside the wheel base (in this case, the distance between the wheels of the sail car).

Page 12: Workshop III-Sail Car: The instructions include applying tape to the base frame pieces, but fail to show where it should be applied. Our sail car worked well without the tape.

Page 15: Experiments 5 Weight = Gravitational Force and 6 Gravitational Force Raises Fall Speed: The description of these two experiments may lead the user to conclude that gravity has been "diluted" by the configuration of the weights. This, however, is not the case. An analysis of the apparatus shows that $a = \frac{m}{2M + m} g$, where a is the acceleration of the mass m with the two large sprocket masses having mass M each, and g is the acceleration due to gravity. Note that the right hand side is a function of m and therefore the acceleration varies every time m is changed. Galileo effectively "diluted" gravity using an inclined plane, which for a fixed angle gives the same acceleration for all masses m; thereby showing that the acceleration due to gravity is independent of the mass of the falling object.

Page 17: Inert Mass and Gimbal: This should be written Mass Inertia and Gimbal. Also the sentence "You can sense that yourself when you pull yourself out of a deep sleep early in the morning and have to get up, even though you still feel sluggish and totally without the energy to do so." is not acceptable in describing physics or physical systems. Physics uses terms with precise definitions even if the words may be shared with common usage. A good physicist does not mix common usage with physics terms.

Page 16: Workshop VI – Force Scale 0 to 7.5 Newtons: We constructed the force scale and found that the elastic was not calibrated to provide forces between 0.0 and 7.5 Newtons. A water bottle containing 16.9 ounces of water should have a force of 4.698 Newtons. Our Force Scale went to the maximum reading and would have gone further if it had not stopped at the pin.

Page 21: Experiment 9: I recommend dropping a ball synchronized with shooting the ball with an arching trajectory to compare the time for both to hit the ground. This will show that the vertical component of the trajectory is independent of the horizontal component of the trajectory.

Page 22: The use of kilograms as a unit of force is incorrect. Force is measured in Newtons and a kilogram is a unit of mass.

Page 27: Experiment 14: "The force of the weight is distributed into two individual forces." This statement needs a picture or graph to explain that the forces are parallel and perpendicular to the plane.

Page 28: "At first you need a big show of strength, and then it gets easier." This would be better said as follows: A larger force is needed to accelerate the object from rest (to overcome static friction) than to keep it moving (to overcome kinetic friction).

Page 51: The use of elastic and inelastic with regard to collisions should be clarified. An elastic collision involves little or no deformation of the objects in collision. An elastic collision obeys both conservation of momentum and kinetic energy. On the other hand, inelastic collisions involve large deformations and in fact can include the merging of two colliding objects. Inelastic collisions obey the conservation of momentum but not the conservation of energy. Some of the energy is converted, for example, into heat, sound, and or light.

Page 62: The word inert should be replaced by rotational inertia and moment of inertia as is appropriate in these sections.

Physics Workshop Quiz: A quiz is provided to test the user on the workshop topics. Many of the answers provided refer the user back to the manual for the answer. Question 4 asks “How can you determine the approximate depth using just simple tools?” The manual’s answer is “b. With a stone and stopwatch.” However, the answer also goes on to explain the method in more detail and confuses the speed of the object with the distance traveled. A more careful analysis shows that the stone falls 50 m in 3.16 s and 100 m in 4.47 s. This comes from the equation $s = \frac{1}{2}at^2$. Then solve for t to get $t = \sqrt{2s/a}$, where a is the acceleration due to gravity which is $9.81 m/s^2$ and is approximated in the manual during computations by $10.0 m/s^2$.

List of materials supplied by user

1. sail material – plastic bag, light weight cloth etc.
2. tea light – candle
3. paper clips – wire cutter and pliers
4. potato
5. tooth pick or matchstick
6. dental floss or sewing thread
7. card board – cut in strips
8. cord 3 m long and 1 mm thick
9. tape
10. rubber band – to be cut
11. _ liter bottle
12. film container
13. glue
14. liquid soap
15. sand paper
16. bamboo pole
17. nail file
18. wood plank for an inclined plane
19. C-cell battery

III. Conclusions

While I have made a number of comments and suggestions regarding the Physics Workshop, I highly recommend it for those interested in physics and engineering. It provides the user with a sense of the kind of problems that can occur in constructing apparatus and performing experiments. It also shows that physics is all around us in its application to everyday problems. The Physics Workshop is also fun. As mentioned above, the apparatus may be used to show other physical principles and be modified to build your own engineering applications to problems you see. Perhaps Thames and Kosmos will design Physics Workshops for other areas of physics.

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