Physics

Energy & Machines Homework

1. How much work is done on a 2538 kg car if a kid applies 10 newtons of force to it, but it doesn't move? What if a man applies 47 newtons of force to the same car while it moves 10 meters?
2. What happened to the chemical potential energy converted by the kid's muscles in **Problem #1**? How about the CPE in the man's muscles?
3. Who does more work lifting a 100 pound barbell over their head, a 5 foot man or a 6 foot man (or is the work the same for both)? Justify your answer.
4. How much force must you apply to a 15 kg rock in order to lift it from the floor and place it atop a 1.1 meter table? (Technically, you have to apply just a tiny bit more than this force.)
5. Calculate the amount of work done on the rock in **Problem #4**. Would the frame of reference you choose make a difference in your answer?
6. How much gravitational potential energy does a 15 kg rock have when it's sitting atop a 1.1 meter table? Describe the reference frame you chose for this problem. Give an example of how your answer might change if you changed your frame of reference.
7. How much heat would be released if the rock in **Problem #5** fell off the table and onto the floor?
8. How much power does an engine that does 6000 joules of work every minute produce? How long would it take this engine to raise a 3.0 kg mass to a height of 12 meters?
9. Calculate the amount of electric potential energy consumed by an electric motor in 15 minutes if it draws 250 watts from the power grid.
10. Assuming the engine in **Problem #8** is actually the electric motor in **Problem #9**, calculate its mechanical efficiency.
11. How much gravitational potential energy does a 2 kg rock have when it's sitting on top of a 2 meter platform? How much kinetic energy does it have? Suppose somebody pushes the rock off the table, and it falls to the floor. Answer the same two questions for the point just **before** the rock hits the floor.
12. At what point in the motion of a pendulum is its potential energy greatest? At what point is its kinetic energy greatest? Draw a diagram showing the point at which its kinetic energy is exactly half of its maximum value. How much potential energy does it have at this point?
13. Complete the **Conservation of Energy** practice sheet.
14. A car moving at 20 mph has 100,000 joules of kinetic energy. How much kinetic energy would it have if it were moving at 40 mph? Suppose it takes the car 40 feet to stop if it's going 20 mph. How far will it take to stop if it's going 40 mph?
15. Calculate the kinetic energy of a 10 kg rock moving at 30 meters per second. How about the KE of a 20 kg rock moving at 30 meters per second? How about the KE of a 10 kg rock moving at 60 meters per second?
16. A pair of identical clay lumps collide and come to rest. Is momentum conserved? Is kinetic energy conserved?
17. Does a car burn more gasoline when its lights are turned on? Explain why or why not.

18. An inefficient engine is said to waste energy. Dos this mean that energy is destroyed? If not, where does this energy go?
19. A man uses a pulley system to raise a 100 kg object 1.5 meters off the floor. If the mechanical efficiency of the system is 100%, and the man only applies 25 newtons of force, how far does he pull his end of the rope? How much force would he have to apply if the pulley system was only 75% efficient?
20. Scissors for cutting paper have long blades and short handles, whereas metal-cutting shears have long handles and short blades. Bolt cutters have very long handles and very short blades. Explain why this is so.
21. By how much does the gravitational force decrease when the distance between the centers of the two objects is doubled? How much if it is tripled? Increased tenfold?
22. An apple in a tree weighs 1 newton. If the tree were twice as tall, would the apple weigh only 0.25 newtons? Justify your answer using the Universal Law of Gravitation.
23. Calculate the weight of a 3.0 kg object on the surface of the Earth using the Universal Law of Gravitation. Assume that the Earth has a mass of 5.98×10^{24} kg and that the Earth's radius at the location of the object is 6,370 km. Check your answer using the weight formula we learned in the previous section.
24. Which will roll down a ramp faster, a volleyball or a bowling ball? Justify your answer by carefully considering **both** of the following for each ball: the moment of inertia and the force applied by gravity.
25. Which position of a spinning figure skater gives her a greater moment of inertia: hands on her head, hands flat against her sides, or arms extended horizontally? As she shifts between the three positions, how does her angular velocity change? Explain this using the conservation of angular momentum. Why can't the same kind of thing be demonstrated for the conservation of linear momentum?
26. Compute the torque applied to a wheel lug bolt when a 100 kg man sits on the end of a 0.25-meter lug wrench. How much force must be applied to get the same torque if a "breaker bar" is used to extend the wrench to a total length of 1.0 meter?
27. Complete the **Rotational Motion – Torques** practice sheet.
28. Suppose that the skater in **Problem #25** is initially stationary with her arms (each 0.50 meters long) extended, and that her shoulder width is 0.40 meters. How much torque would result from a 45-newton push applied perpendicular to one arm at the very tips of her fingers? Calculate the change in her angular momentum if that force was applied for 3 seconds.
29. Suppose that with her arms extended, the same skater's moment of inertia is $2\text{kg} \cdot \text{meter}^2$. Calculate her angular velocity after the force in **Problem #28** has been applied for 3 seconds. Calculate her angular KE at the same time.