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Current Course
Course Home
Edit Course Info
Syllabus/Assignments
Grades
Student administration
Instructor administration

My Courses
AP Physics B
AP Physics C
Honors Physics
ePhysicsC
ePhysicsE

My Account
Change password
Manage courses

Homework Home
Logout

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Chapter 7: Work, Energy and Power

Conceptual problems

7.C.1 **(5.00)** You take your backpack out of the car, hike to the top of a nearby mountain, and return with your backpack to your car at the bottom. Have you changed the amount of your backpack's mechanical energy?

○ Yes ○ No

7.C.2 **(5.00)** There are two slides at the park between which you are deciding. Both start at a height of 6 m. One is short and steep while the other is long and shallow. If both slides are frictionless, which one should you choose if you want to be moving as fast as possible at the bottom?

7.C.3 **(5.00)** A skydiver jumps out of a plane. Does the mechanical energy of the jumper change while she is falling? Ignore the effects of air resistance.

○ Yes ○ No

7.C.4 **(5.00)** At the gym, your trainer places a 8.0 kg dumbbell in each of your outstreched hands. You hold them there for 20 seconds. Have you done any work during those 20 seconds?

○ Yes ○ No

7.C.5 **(5.00)** Two boxes of the same mass are lifted to the same height. Does it necessarily take the same amount of power to lift each box?

○ Yes ○ No

Section 0: Introduction

7.0.1 **(5.00)** Use the simulation in the interactive problem in Section 7.0 to answer the following questions. (a) If you release the car at a higher point, will its speed at the bottom of the hill be greater, the same, or less? (b) How high will you have to drag the car to have it just reach the summit of the other hill: to the same height, higher or lower?

(a) [ ]
(b) [ ]

Section 1: Work

7.1.1 An airline pilot pulls her 12.0 kg rollaboard suitcase along the ground with a
(5.00) force of 25.0 N for 10.0 meters. The handle she pulls on makes an angle of *theta* degrees with the horizontal. How much work does she do over the ten-meter distance?

[ ] J

7.1.2 A parent pushes a baby stroller from home to daycare along a level road with
(5.00) a force of *F* N directed at an angle of 30° below the horizontal. If daycare is 0.83 km from home, how much work is done by the parent?

[ ] J

Section 2: Dot product

7.2.1 Vector **v** has a magnitude of *v* m and vector **u** has a magnitude of 77 m. The
(5.00) angle between **v** and **u** is 150°. What is **v**·**u**?

[ ] m^2

7.2.2 Find the dot product of (2, 3) and (4, −7).
(5.00)

[ ]

Section 3: Work done by a variable force

7.3.1 The graph shown describes a certain force that is exerted on an object, as a
(5.00) function of the position of the object. How much work is done by this force as the object moves from the position 0.0 m to 6.0 m?

[ ] J

Section 6: Kinetic energy

7.6.1 **(5.00)** You are about shoot two identical cannonballs straight up into the air. The first cannonball has *x* times as much initial velocity as the second. How many times higher will the first cannonball go compared to the second?

[ ] times higher

7.6.2 **(5.00)** What is the change in kinetic energy of a baseball as it accelerates from rest to 45.0 m/s? The mass of a baseball is 145 grams.

[ ] J

7.6.3 **(5.00)** A bullet of mass 10.8 g leaves a gun barrel with a velocity of 511 m/s. What is the bullet's kinetic energy?

[ ] J

Section 7: Work-kinetic energy theorem

7.7.1 **(5.00)** A net force of 1.6×10^{-15} N acts on an electron over a displacement of 5.0 cm, in the same direction as the net force. (a) What is the change in kinetic energy of the electron? (b) If the electron was initially at rest, what is the speed of the electron? An electron has a mass of 9.1×10^{-31} kg.

(a) [ ] J
(b) [ ] m/s

7.7.2 **(5.00)** A proton is moving at 425 m/s. (a) How much work must be done on it to stop it? (A proton has a mass of 1.67×10^{-27} kg.) (b) Assume the net braking force acting on it has magnitude 8.01×10^{-16} N and is directed opposite to its initial velocity. Over what distance must the force be applied? Watch your negative signs in this problem.

(a) [ ] J
(b) [ ] m

7.7.5 **(7.00)** A 25.0 kg projectile is fired by accelerating it with an electromagnetic rail gun on the Earth's surface. The rail makes a 30.0 degree angle with the horizontal, and the gun applies a 1250 N force on the projectile for a distance of 7.50 m along the rail. (a) Ignoring air resistance and friction, what is the net work done on the projectile, by all the forces acting on it, as it moves 7.50 m along the rail? (b) Assuming it started at rest, what is its speed after it has moved the 7.50 m?

(a) [ ] J
(b) [ ] m/s

Section 12: Power

7.12.1 **(5.00)** How much power would be required to hoist a 48 kg couch up to a *h* m high balcony in 5.0 seconds? Assume it starts and ends at rest.

[ ] W

7.12.2 **(5.00)** Stuntman's Freefall, a ride at Six Flags Great Adventure in New Jersey, stands 39.6 meters high. Ignoring the force of friction, what is the minimum power rating of the motor that raises the 1.20×10^5 kg ride from the ground to the top in 10.0 seconds at a constant velocity?

[ ] W

7.12.4 **(5.00)** A power plant supplies 1,100 megawatts of power to the electric grid. How many joules of energy does it supply each second?

[ ] J

7.12.6 **(7.00)** The Porsche® 911 GT3 has a 380 hp engine and a mass of 1.4×10^3 kg. The car can accelerate from 0 to 100 km/h in 4.3 seconds. What percentage of the power supplied by the engine goes into making the car move? Assume that the car's acceleration is constant and that there are 746 Watts/hp.

[ ] %

Section 14: Work and gravitational potential energy

7.14.1 **(5.00)** You lower a 2.50 kg textbook (remember when textbooks used to be made out of paper instead of being digital?) from a height of *h* m to 1.50 m. What is its change in potential energy?

[ ] J

7.14.2 **(5.00)** The reservoir behind the Grand Coulee dam in the state of Washington holds water with a total gravitational potential energy of 1×10^{16} J, where the reference point for zero potential energy is taken as the height of the base of the dam. (a) Suppose that the dam released all its water, which flowed to form a still pool at the base of the dam. What would be the change in the gravitational potential energy of the Earth-dam-water system? (b) What work was done by the gravitational force? (Part of this work is ordinarily used to turn electric generators.) (c) How much work would it take to pump all the water back up into the reservoir?

(a) [ ] J
(b) [ ] J
(c) [ ] J

7.14.3 **(5.00)** What is the change in the gravitational potential energy of a Boeing 767 jet as it soars from the runway up to a cruising altitude of 10.2 km? Assume its mass is a constant 2.04×10^5 kg.

J

Section 19: Conservation of energy

7.19.1 **(5.00)** A large block of ice is moving down the hill toward you at 25.0 m/s. Its mass is 125 kg. It is sliding down a slope that makes a 30.0 degree angle with the horizontal. In short: Think avalanche. Assume the block started stationary and moves down the hill with zero friction. How many meters has it been sliding?

m

Section 20: Sample problem: conservation of energy

7.20.1 **(10.00)** A spring has its right end fixed and is installed on a horizontal table so that the free end, in equilibrium, is at x = 3.00 m. A 1.65 kg block coming from the left slides along the table. When it passes the origin, it is moving at 5.58 m/s. It strikes the spring, compresses it momentarily, and is then sent back toward the left, where it eventually comes to rest at the point x = 1.50 m. The coefficient of kinetic friction between the block and the table is 0.300. By what distance was the spring compressed?

m

Additional problems

7.A.9 **(7.00)** The Queen Mary 2, whose maiden voyage was in January 2004, is a cruise ship that has a mass of 150,000 gross tons (which equals 1.52×10^8 kg, about three times that of the Titanic). Her electrically driven pod motors have a maximum power rating of 1.57×10^5 hp, or 117 MW. (a) What is the kinetic energy of the QM2 when she is moving at 15.0 meters/second? (b) Find the absolute minimum time in which the ship's engines could accelerate her from rest up to 15.0 m/s. Ignore the drag resistance of the water, air, and so on. (c) What is the force that the ship's propellers exert on the water when the Queen Mary 2 is moving at 15.0 m/s (assume that the maximum power is used)?

(a) J

(b) s

(c) N

7.A.10 **(7.00)** Lance Armstrong bikes at a constant speed up the *Alpe d'Huez*, a famous mountain pass. Assume his teammates do such a good job riding ahead of him that he can draft behind them and encounter no air resistance. This climb is described as "beyond classification" in terms of its difficulty. The climb is 13.8 km long at a 7.9% average grade (the grade, as a decimal, is the tangent of the angle of inclination). Assume that the combined mass of Lance and his bicycle is 83 kilograms. What is the magnitude of the work he does against the force of gravity?

J

7.A.12 **(7.00)** Lamborghini states that its 2004 Murciélago® has a mass of 1650 kg. On a particular test run, its 580 hp (433 kW) engine accelerates the car from 0 to 100 km/h (62 mph) in 3.60 seconds. Assume the engine is working at its maximum power. How much energy is consumed by dissipative forces like air resistance and friction as the car accelerates from 0 to 100 km/h?

J

Back to assignments list

Current server time is: 2008-02-17 16:27