Instructions:

All diagrams and figures on this homework are rough sketches: they are not generally drawn to scale. Your answers should be based on the numbers given, not on measurements made with a ruler or protractor.

This homework set consists of 50 multiple-choice problems. You are to be your own grader for the homework. You will find solutions to these problems on the website underneath the homework set itself. The solutions are broken into two parts: the answer key (i.e., just the answers), and on the following pages the worked out solutions. Since you have access to all of the solutions, I will not grade the homework.

The idea is that you should work the problems, then circle the answers on the grade sheet that is located on page two of the homework. When you are finished with a section, you should then compare your solutions to the answers on the answer key of the corresponding homework solution set.

If you miss any of the problems, then you should look up the solution, check to see what you did wrong, and correct it. You should keep track of which problems you miss. A good way to do this is to take the grade sheet with your solutions on it and place a large red X on the number of the problem that you missed.

If you don’t understand the solution, then you should seek help. If you miss lots of similar type problems, then you should go to my large problem bank and work more similar type problems.

You should do your work either on the space provided or on scratch paper and then recopy it over to a notebook or ringed binder. You should not try to squeeze your work onto the small space between the problems on this homework set.

This homework set is for practice only. It has no due date since I do not grade homework. However, if you write the solutions out with all of your work clearly labelled, neatly written, and all in one notebook or binder (a.k.a., a homework portfolio) as described in the syllabus, then I will take this into consideration should you find yourself on the border between two grades. I will not ask to see your portfolio until the end of the semester.
Directions: Work the problems, then circle your answers below.

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Work, Energy, and Momentum

Work

Problem 1. A rifle bullet is fired straight upward. As it rises, the work done by gravity on the bullet is:
(a) positive (b) negative (c) zero

Problem 2. A physics student drops a cell phone down a mineshaft. The work done by gravity on the phone is:
(a) positive (b) negative (c) zero

Problem 3. A skateboarder takes his dog for a walk by standing on his skateboard, holding the dog’s leash, and allowing her to tow him along the sidewalk. The tension in the leash is 200 N, and the leash makes an angle of 20° with the horizontal. How much work does the dog do in towing the skateboarder 300 m? Round your answer to two significant figures.
(a) 21,000 J (b) 56,000 J (c) 150,000 J (d) 430,000 J (e) none of these

Problem 4. A road runs beside and parallel to a straight stretch of railroad track. A train robber attaches his pickup truck to a boxcar, using a horizontal rope that makes an angle of 15° to the tracks, and tows the boxcar 500 m down the tracks. If the tension in the rope was 2000 N, how much work was done on the boxcar? Give your answer in scientific notation, rounded to two significant figures.
(a) $2.6 \times 10^5$ J (b) $6.5 \times 10^5$ J (c) $7.6 \times 10^5$ J (d) $9.7 \times 10^5$ J (e) none of these

Kinetic energy

Problem 5. A bird with a mass of 1.3 kg is flying at a speed of 15 m/s. What is the bird’s kinetic energy? Round your answer to two significant figures.
(a) 100 J (b) 150 J (c) 200 J (d) 270 J (e) none of these
Problem 6. You are testing your new potato gun at the ballistics lab. You fire a potato with a mass of 0.6 kg into a ballistic pendulum, and discover that the kinetic energy of the potato was 60 J. What was the speed of the potato? Round your answer to the nearest m/s.

(a) 12 m/s  
(b) 14 m/s  
(c) 16 m/s  
(d) 18 m/s  
(e) none of these

Potential energy

Problem 7. A toolbox has a mass of 12 kg. You pick it up from the ground and place it on top of a stool 80 cm high. How much did you increase the potential energy of the toolbox? For ease of calculation, assume that \( g = 10 \text{ m/s}^2 \). Round your answer to two significant figures.

(a) 48 J  
(b) 68 J  
(c) 96 J  
(d) 140 J  
(e) none of these

Problem 8. You carry 40 kg of physics books from the parking lot to your instructor’s office, 5 m above ground level. By how much did you increase the gravitational potential energy of the books? For ease of calculation, assume that \( g = 10 \text{ m/s}^2 \).

(a) 500 J  
(b) 800 J  
(c) 1000 J  
(d) 2000 J  
(e) none of these

Work-Mechanical-Energy theorem

Work-kinetic

Problem 9. A car has a weight of 12,000 N. The coefficient of kinetic friction between its wheels and the wet highway is 0.5. The car is travelling at 20 m/s when the driver locks up the brakes. How far does the car travel before it comes to a complete stop? Round your answer to the nearest meter. For ease of calculation, assume that \( g = 10 \text{ m/s}^2 \).

(a) 40 m  
(b) 60 m  
(c) 80 m  
(d) 120 m  
(e) none of these
Problem 10. A bartender slides a glass of beer with a mass of 500 g along the top of a level bar. The coefficient of kinetic friction between the glass and the bar is \( \mu_k = 0.12 \). When the glass leaves the bartender’s hand, it is moving at a speed of \( v_0 = 2.5 \) m/s. How far does the glass travel before coming to a stop? For ease of calculation, assume that \( g = 10 \) m/s\(^2\). Round your answer to two significant figures.

(a) 2.3 m (b) 2.6 m (c) 2.9 m (d) 3.2 m (e) none of these

Problem 11. You are driving at a speed of \( V \) on a level highway. If the road is dry, you can stop in a distance of \( x_d \); if it is wet, you need \( x_w = 2x_d \) to stop. The coefficient of kinetic friction between your tires and the pavement is \( \mu_d \) if the road is dry; \( \mu_w \) if the road is wet. What is the relationship between \( \mu_d \) and \( \mu_w \)?

(a) \( \mu_d = 4\mu_w \) (b) \( \mu_d = 2\mu_w \) (c) \( \mu_d = \sqrt{2}\mu_w \) (d) \( \mu_d = \sqrt{2\mu_w} \) (e) none of these

work-potential

Problem 12. With no force applied to it, a spring hanging from the ceiling is 40 cm long. You hang a weight of 400 N from it, stretching it to a length of 50 cm. How much work was done by gravity in stretching the spring?

(a) 1.25 J (b) 2.5 J (c) 5 J (d) 20 J (e) none of these

Problem 13. An unstretched bungee cord with spring constant \( k = 8000 \) N/m is 30 cm long. You pull on it, stretching it to a length of 35 cm. How much energy is stored in the stretched cord? Round your answer to two significant figures.

(a) 10 J (b) 20 J (c) 490 J (d) 980 J (e) none of these

Problem 14. An unstretched spring is 0.24 m long. When a force that increases to 600 N is applied, it stretches until its total length is 0.30 m. How much work does it take to stretch the spring to this length? Round your answer to two significant figures.

(a) 15 J (b) 16 J (c) 18 J (d) 20 J (e) none of these
Conservation of mechanical energy

Problem 15. A spring cannon is used to launch two balls straight upward: first, a ball with mass $M$; then a ball with mass $2M$. The spring in the cannon is compressed by the same amount in both launchings. Which of the following statements is true?

(a) The two balls leave the spring cannon with the same kinetic energy.
(b) The larger ball leaves the spring cannon at a higher speed than the smaller ball.
(c) The two balls reach the same maximum height.
(d) At their maximum heights, the smaller ball has greater potential energy than the larger ball.

Problem 16. A mountain rising from a level plain has two faces. The north face is a sheer cliff; the south face is an icy slope of 45°. Two identical boulders are pushed off the summit of the mountain: one off the cliff to the north, the other down the frictionless slope to the south. When they reach the bottom of the mountain, the north boulder is moving at speed $v_N$; the south boulder is moving at speed $v_S$. What is the relationship between the two speeds?

(a) $v_N = v_S$
(b) $v_N = v_S \sin 45°$
(c) $v_S = v_N \sin 45°$
(d) $v_S = \sqrt{2} v_N$
(e) none of these

Problem 17. The surface gravity on Planet X is $g_X$. An astronaut standing on the surface of the planet fires a bullet with mass $m$ straight upward with kinetic energy $K$. What is the maximum height $h_{\text{max}}$ reached by the bullet?

(a) $\sqrt{\frac{K}{mg_X}}$
(b) $\sqrt{\frac{2K}{mg_X}}$
(c) $\frac{K}{mg_X}$
(d) $\frac{2K}{\sqrt{mg_X}}$
(e) none of these

Problem 18. Starting from rest atop a hill 25 m high, a skier slides down an icy slope that makes an angle of 30° with the horizontal. How fast is he moving when he reaches the base of the hill? For ease of calculation, assume that $g = 10$ m/s$^2$. Round your answer to two significant figures.

(a) 16 m/s
(b) 18 m/s
(c) 20 m/s
(d) 22 m/s
(e) none of these
Problem 19. Ricky, the 10 kg snowboarding raccoon, is on his snowboard atop a frictionless ice-covered quarter-pipe with radius 6 meters (see figure at right). If he starts from rest at the top of the quarter-pipe, what is his speed at the bottom of the quarter-pipe? For ease of calculation, assume that \( g = 10 \text{ m/s}^2 \). Round your answer to the nearest m/s.

(a) 11 m/s  
(b) 12 m/s  
(c) 13 m/s  
(d) 14 m/s  
(e) none of these

Problem 20. A frictionless horizontal air track has a spring at either end. The spring on the left has a force constant of 8000 N/m; the one on the right has a force constant of 6000 N/m. A glider with a mass of 500 g is pressed against the left-hand spring, compressing it by 2.5 cm. The glider is then released, so that the spring propels it rightward. It slides along the track and into the right-hand spring. What is the maximum compression of the right-hand spring? Round your answer to the nearest 0.1 cm. (The diagram following the answers shows the situation before the glider is released, when the left-hand spring is compressed and the glider is not moving.)

(a) 2.9 cm  
(b) 3.2 cm  
(c) 3.5 cm  
(d) 3.8 cm  
(e) none of these

Computations with momentum

Problem 21. A ball with a mass of 400 g is thrown at a speed of 20 m/s. What is the ball’s momentum? Round your answer to two significant figures.

(a) 8.0 kg m/s  
(b) 16 kg m/s  
(c) 40 kg m/s  
(d) 80 kg m/s  
(e) none of these

Problem 22. A bicyclist with a mass of 100 kg has a momentum of 1500 kg m/s. What is the bicyclist’s speed? Round your answer to two significant figures.

(a) 3.9 m/s  
(b) 5.5 m/s  
(c) 15 m/s  
(d) 21 m/s  
(e) none of these
Problem 23. A bicyclist with a mass of 120 kg is moving at a speed of 4 m/s. What is his momentum?

(a) 30 kg m/s  
(b) 240 kg m/s  
(c) 480 kg m/s  
(d) 600 kg m/s  
(e) none of these

Problem 24. A shopping cart has a mass of 15 kg. It is rolling across a level parking lot, with a momentum of 40 kg m/s. What is the cart’s speed? Round your answer to the nearest 0.1 m/s.

(a) 2.7 m/s  
(b) 2.9 m/s  
(c) 3.2 m/s  
(d) 3.5 m/s  
(e) none of these

Conservation of momentum

Problem 25. An apple falls off a branch. Which property of the apple is conserved as it falls? Assume that there is no air resistance.

(a) Potential energy  
(b) Kinetic energy  
(c) Mechanical energy  
(d) Momentum

Problem 26. A skier slides down a frictionless slope. As he descends, which of the quantities of the skier is conserved?

(a) Momentum  
(b) Mechanical energy  
(c) Potential energy  
(d) Kinetic energy

Problem 27. A cannon has a mass of 1200 kg. It fires a cannonball with a mass of 4 kg at a muzzle velocity of 350 m/s. How fast does the cannon move backward when the ball is fired? Round your answer to two significant digits.

(a) 0.9 m/s  
(b) 1.1 m/s  
(c) 1.2 m/s  
(d) 1.3 m/s  
(e) none of these

Problem 28. A cannon has a mass of 1000 kg. It fires a cannonball with a mass of 4 kg at a muzzle velocity of 300 m/s. How fast does the cannon move backward when the ball is fired? Round your answer to two significant digits.

(a) 0.6 m/s  
(b) 1.2 m/s  
(c) 1.8 m/s  
(d) 2.4 m/s  
(e) none of these
Impulse

Problem 29. A crate of auto parts is at rest on the surface of a frozen lake. A horizontal force of 50 N is applied to the crate for 7 s. At the end of this time, what is the crate’s momentum? Round your answer to two significant figures.

(a) 350 kg m/s  
(b) 700 kg m/s

(c) 1200 kg m/s  
(d) 2500 kg m/s

(e) none of these

Problem 30. A ball weighing 1 kg and moving horizontally at 10 m/s strikes a wall and rebounds horizontally at 10 m/s. What is the magnitude of the impulse that the wall gives to the ball? Round your answer to two significant digits.

(a) 0 kg m/s  
(b) 10 kg m/s

(c) 20 kg m/s  
(d) 5 kg m/s

(e) none of these

Collisions

Problem 31. (Lab Problem) Two gliders collide on a frictionless horizontal air track. If the collision is \textit{elastic}, which of the following statements must be true?

(a) Momentum and kinetic energy are both conserved.

(b) Kinetic energy is conserved; momentum is not conserved

(c) Momentum is conserved; kinetic energy is not conserved.

(d) Neither momentum nor kinetic energy is conserved.

Problem 32. Two gliders collide on a horizontal frictionless air track. If the collision is \textit{inelastic}, which of the following statements must be true?

(a) Momentum and kinetic energy are both conserved.

(b) Momentum is conserved; kinetic energy is not conserved.

(c) Kinetic energy is conserved; momentum is not conserved

(d) Neither momentum nor kinetic energy is conserved.
Problem 33. (Lab Problem) A glider with a mass of 500 g is at rest on a frictionless horizontal air track. A second glider with a mass of 250 g is launched toward it at a speed of \( V \). The second glider has a spring attached, which is compressed as it collides with the first glider. When the spring is at its maximum compression, which of the following statements is true?

(a) The second glider is at rest relative to the ground.
(b) Both gliders have the same velocity.
(c) Both gliders have the same momentum.
(d) Both gliders have the same kinetic energy.

Problem 34. Two gliders collide on a frictionless horizontal air track. The first glider’s mass is 100 g; before the collision, it is moving rightward at 4 m/s. The second glider’s mass is 200 g; before the collision, it is moving rightward at 1 m/s. After the collision, the first glider is at rest. What is the second glider’s speed after the collision?

(a) 1 m/s (b) 2 m/s (c) 3 m/s (d) 4 m/s (e) none of these

Problem 35. Two gliders collide on a frictionless horizontal air track. The first glider has a mass of 2 kg; before the collision, it is moving rightward at 5 m/s. The second glider has a mass of 3 kg; before the collision, it is at rest. After the collision, the second glider is moving rightward at 4 m/s. What is the velocity of the first glider after the collision?

(a) 1 m/s leftward (b) 1 m/s rightward (c) 3 m/s leftward (d) 3 m/s rightward (e) none of these

Problem 36. A block of wood with a mass of 1300 g is sitting on a horizontal tabletop. The coefficient of kinetic friction between the block and the table is \( \mu_k = 0.74 \). A rifle bullet with a mass of 39 g is fired horizontally into the block at a speed of 290 m/s and stops inside the block. How far does the block with the bullet embedded in it slide before coming to a stop? Round your answer to the nearest 0.1 m.

(a) 4.4 m (b) 4.9 m (c) 5.4 m (d) 6.0 m (e) none of these
Problem 37. (Lab Problem) At either end of a frictionless horizontal air track is a spring with a force constant of 2100 N/m. A glider with a mass of 2.55 kg is pressed against the left-hand spring, compressing it by 0.071 m. The glider is then released, so that the spring propels it rightward. In the middle of the track is a second glider with a mass of 1.60 kg. The two gliders have small magnets attached, so when the first glider strikes the second, they stick together and slide into the right-hand spring. What is the maximum compression of the right-hand spring? Round your answer to the nearest 0.001 m. (The diagram shows the situation before the left-hand glider is released, when the left-hand spring is compressed and neither glider is moving.)

(a) 1.024 m  (b) 0.056 m  
(c) 0.431 m  (d) 0.581 m  
(e) none of these

Conservation of angular momentum

Problem 38. A physics student is standing at the outer edge of a merry-go-round that is rotating frictionlessly. The student walks across the merry-go-round to the opposite edge. How does the merry-go-round’s angular speed change as the student crosses it?

(a) The merry-go-round speeds up as the student approaches the center, then slows down again as he moves toward the opposite edge.
(b) The merry-go-round slows down as the student approaches the center, then speeds up again as he moves toward the opposite edge.
(c) The merry-go-round speeds up as long as the student keeps walking.
(d) The merry-go-round slows down as long as the student keeps walking.

Problem 39. A merry-go-round’s moment of inertia is 400 kg·m²; its radius is 2 m. It is initially at rest. A physics student with a mass of 60 kg is standing on the outer edge. The student jumps off at 2.5 m/s, in a direction tangent to the outer edge. After the student has jumped off, how long does it take for the merry-go-round to make one complete revolution? Round your answer to two significant figures.

(a) 7.5 s  (b) 8.4 s
(c) 9.1 s  (d) 9.8 s
(e) none of these
Problem 40. A door’s moment of inertia is 8 kg·m². A bullet with a mass of 25 g, moving horizontally at 300 m/s, strikes the door at an angle of 60° to the door’s surface, at a distance of 75 cm from the hinges. The bullet remains embedded in the door. What is the door’s angular speed after the collision? Assume that the embedded bullet does not change the door’s moment of inertia. Round your answer to two significant figures.

(a) 0.55 rad/s  (b) 0.61 rad/s
(c) 0.67 rad/s  (d) 0.74 rad/s
(e) none of these

Harmonic Motion

Problem 41. A pendulum goes through 20 complete cycles in 60 seconds. What is its frequency?

(a) $\frac{1}{3}$ Hz  (b) $\frac{2\pi}{3}$ Hz
(c) 3 Hz  (d) $\frac{3}{2\pi}$ Hz
(e) none of these

Problem 42. An oscillator is made using a 10 kg block sliding on a frictionless horizontal surface, attached to a horizontal spring with a force constant of 4000 N/m. The spring is initially stretched by 10 cm and held for a moment, then released. As the block oscillates, what is its maximum speed?

(a) 1 m/s  (b) 2 m/s
(c) 4 m/s  (d) 8 m/s
(e) none of these

Problem 43. An oscillator is made using a 5 kg mass sliding on a frictionless horizontal surface, attached to a horizontal spring with a force constant of 20 N/m. What is the period of the oscillator in seconds?

(a) 1 s  (b) $\pi$ s
(c) 2 s  (d) $2\pi$ s
(e) none of these

Problem 44. An astronaut moves his furniture to Planet X. On Earth, the pendulum in his grandfather clock has a period of 1.0 s. On Planet X, the pendulum’s period is 0.5 s. What is the gravitational acceleration $g_X$ of Planet X in terms of Earth’s gravity $g_E$?

(a) $g_E/4$  (b) $g_E/2$
(c) $2g_E$  (d) $4g_E$
(e) none of these
Mechanical waves and sound

Problem 45. A tsunami consists of a series of waves travelling at a speed of 800 km/hr, with a wavelength of 200 km. What is the period of the waves?

(a) 15 s       (b) 4 min
(c) 15 min     (d) 4 hr
(e) none of these

Problem 46. A cable with a linear density of 3 kg/m is stretched between two poles 30 m apart. If the cable is plucked, the resulting transverse wave travels from one pole to the other in 1 second. What is the tension in the cable?

(a) 100 N       (b) 300 N
(c) 900 N       (d) 2700 N
(e) none of these

Problem 47. A violin string is tuned so that its third harmonic has a frequency of 1200 Hz. What is the fundamental frequency of the string?

(a) 150 Hz      (b) 400 Hz
(c) 3600 Hz     (d) 9600 Hz
(e) none of these

Problem 48. An obscure stringed instrument has two strings of identical length and composition, called the P and Q strings. The P string has a tension of $T_P$, so that its fundamental frequency is $f_{P1}$. The Q string is tuned so that its fundamental frequency $f_{Q1}$ is the same as the second harmonic of the P string. What is the tension of the Q string?

(a) $T_P/2$     (b) $\sqrt{2} T_P$
(c) 2$T_P$      (d) 4$T_P$
(e) none of these

Problem 49. A violinist is playing a note with a frequency of 480 Hz. The violinist next to him is playing a note with a frequency of 500 Hz. What is the beat frequency produced by the two notes?

(a) 20 Hz       (b) 460 Hz
(c) 490 Hz      (d) 520 Hz
(e) none of these
Problem 50. Two wires of equal length $L$ are stretched between two supports. Both wires are subjected to the same tension $F_T$. The first wire has a mass of $M$; the second, of $3M$. If the fundamental frequency of the first wire is $f_A$ and that of the second wire is $f_B$, which of the following equations is true?

(a) $f_B = \frac{f_A}{3}$
(b) $f_B = \frac{f_A}{\sqrt{3}}$
(c) $f_B = \sqrt{3} f_A$
(d) $f_B = 3 f_A$
(e) none of these

Power

Problem 51. You are pushing an object with a mass of $m$ across a level floor. The total force of resistance is $F_{\text{res}}$. How much power must you supply to push the object at a constant velocity $v$?

(a) $F_{\text{res}} v$
(b) $F_{\text{res}} v m$
(c) $\frac{F_{\text{res}} v}{m}$
(d) $\frac{m v^2}{2 F_{\text{res}}}$
(e) none of these

Problem 52. (Power) How much power, in kilowatts, must be developed by the electric motor of a 1600-kg car moving at 26 m/s on a level road if the forces of resistance total 720 N? Round your answer to the nearest tenth of a kilowatt.

(a) 95.2 kW
(b) 36.3 kW
(c) 133.2 kW
(d) 18.7 kW
(e) none of these