College Physics
Exam 4 Homework Set
(Newton’s Laws)
For physics students everywhere!

Wayne Hacker
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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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Newton’s Laws

Introduction to Newton’s laws

Problem 1. An object is subjected to a nonzero constant net force $\vec{F}$. Which of the following properties of the object will be constant?
   (a) Acceleration  (b) Position
   (c) Speed        (d) Velocity

Problem 2. An object is moving northward. What do we know about the forces on the object?
   (a) There is a single force on the object, directed northward
   (b) There is a net force on the object, directed northward
   (c) There may be several forces on the object, but the largest is directed northward
   (d) We know nothing about the forces on the object

Problem 3. Your physics instructor asks you to help him push an atomic bomb into the classroom. The bomb weighs 8000 N. You push on it with a horizontal force of 400 N. Which of the following statements is true?
   (a) If the atomic bomb moves across the floor, then you feel it pushing back on you with a force of less than 400 N.
   (b) You feel the atomic bomb pushing back on you with a force of 400 N, whether it moves or not.
   (c) If the atomic bomb does not move, you feel it pushing back on you with a force of 8000 N.
   (d) You feel the atomic bomb pushing back on you with a force of 8000 N, whether it moves or not.

Problem 4. You come into your physics lab and find three weights suspended by thin strings from the ceiling, as shown at right. Which of the following statements is true about the tensions $T_1$, $T_2$, and $T_3$ in the strings?
   (a) $T_1 = T_2 = T_3$
   (b) $T_3 > T_2 > T_1$
   (c) $T_1 > T_2 > T_3$
   (d) $T_3 > T_1 > T_2$

Problem 5. You are standing on a spring scale in an elevator that is moving at a constant speed $V$. Before the elevator started moving, the scale registered your weight as $W$. It now registers a weight of $W_{\text{app}}$. What is the relationship between $W_{\text{app}}$ and $W$?
   (a) $W_{\text{app}} < W$
   (b) $W_{\text{app}} = W$
   (c) $W_{\text{app}} > W$
   (d) Not enough information; it depends on the direction of $\vec{V}$. 
Problem 6. A piano with a weight of 4500 N is resting on a frictionless horizontal ice-covered parking lot. You push on the piano with a constant horizontal force of $F$. Which of the following statements is true?

(a) The piano will not accelerate unless $F > 4500$ N.
(b) The piano will accelerate, no matter how small $F$ is.
(c) The piano will move with constant velocity, because $F$ is constant.
(d) The piano will move as long as you apply $F$; once the force is removed, it will stop.

Problem 7. (Similarity Problem) Consider the following two experiments. In the first experiment you push a block along a level surface at a constant velocity $v_1$. To overcome the friction between the block and the surface, you must apply a constant horizontal force $F_{\text{push},1}$. In the second experiment you push the block at a constant speed $v_2 = 2v_1$ across the same surface. Assuming that the friction is the same as it was the first experiment, which of the following choices best describes the new push force $F_{\text{push},2}$ in terms of the first push force?

(a) A constant force $F_{\text{push},1}$
(b) A constant force $2F_{\text{push},1}$
(c) A force that increases from $F_{\text{push},1}$ to $2F_{\text{push},1}$
(d) A force of zero, since the block does not accelerate.

Problem 8. You are pushing two crates across a level frictionless floor, as shown at right. You apply a horizontal force of 300 N to crate A, which is heavier than crate B. Which of the following statements is true?

(a) The two crates will not move if their weight is greater than 300 N.
(b) Crate A pushes on crate B with more force than crate B pushes on crate A.
(c) Crate A pushes on crate B with a force of 300 N; crate B pushes on crate A with a force of 300 N.
(d) Crate A and crate B push on one another with forces that are equal to one another and less than 300 N.
Applications of Newton’s laws to linear motion

Newton’s laws and kinematics

Problem 9. A box has a mass of 20 kg. It is sitting on an icy sidewalk, which constitutes a horizontal frictionless surface. A horizontal force of 30 N is applied to the box. What is the box’s acceleration? Round your answer to two significant figures.

(a) 0.67 m/s²  
(b) 0.75 m/s²  
(c) 1.5 m/s²  
(d) 3.0 m/s²  
(e) none of these

Problem 10. An astronaut with a mass of 80 kg is floating in space, at rest relative to his space station. His jet pack propels him away from the space station with a force of 20 N. How long must the jet pack operate before the astronaut is moving away from the space station at 5 m/s? Round your answer to the nearest second.

(a) 10 s  
(b) 20 s  
(c) 50 s  
(d) 100 s  
(e) none of these

Problem 11. You are pushing two crates across a frictionless floor, as shown at right. You apply a horizontal force of 400 N to the smaller crate. How much force does the smaller crate exert on the larger one?

(a) 60 N  
(b) 180 N  
(c) 240 N  
(d) 300 N  
(e) none of these
Problem 12. (Accelerometer) A thin string is attached to the ceiling of a car, and a lead sinker with mass $m$ is attached to the free end of the string. The car is going at highway speed when the driver hits the brakes. While the car is slowing down, the string makes an angle of $\theta$ to the vertical. What is the magnitude of the car's acceleration? Take the direction of motion to be the positive $x$-axis and the $y$-axis to point upward.

(a) $-g \tan \theta$  (b) $-mg \tan \theta$
(c) $-\frac{g}{\tan \theta}$  (d) $\frac{mg}{\tan \theta}$
(e) none of these

Static problems

Problem 13. In an attempt to keep bears from eating his food, a hiker stretches a rope between two trees and hangs the food from the rope. The food weighs 75 N; each side of the rope makes an angle of 15° with the horizontal. What is the tension in the rope? Round your answer to the nearest newton.

(a) 130 N  (b) 145 N
(c) 159 N  (d) 175 N
(e) none of these
**Problem 14.** A block with weight \( w = 130 \) N is suspended by two thin ropes, labelled \( A \) and \( B \). Rope \( A \) makes an angle of \( \theta_A = 37^\circ \) with the horizontal; rope \( B \) makes an angle of \( \theta_B = 54^\circ \) with the horizontal. The tension in rope \( A \) is \( T_A \); the tension in rope \( B \) is \( T_B \). Find \( T_B \); round your answer to the nearest newton.

(a) 93 N  
(b) 104 N  
(c) 115 N  
(d) 128 N  
(e) none of these

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**Problem 15.** A block with mass \( m_1 \) is on a frictionless ramp that makes an angle of \( \theta \) to the horizontal. A thin string runs from the block, parallel to the ramp, up and over a massless frictionless pulley, and down to a hanging block with mass \( m_2 \). The system is held in place, then released. If the blocks do not move after the release, which of the following must be true?

(a) \( m_1 = m_2 \sin \theta \)  
(b) \( m_2 = m_1 \sin \theta \)  
(c) \( m_1 = m_2 \cos \theta \)  
(d) \( m_2 = m_1 \cos \theta \)  
(e) none of these
Weight

**Problem 16.** A uniform chain is 5.0 m long and has a mass of 50 kg. It hangs from the ceiling and supports a lamp with a mass of 80 kg. What is the tension in the bottom link of the chain? For ease of calculation, assume that $g = 10 \text{ m/s}^2$.

(a) 200 N  
(b) 600 N  
(c) 700 N  
(d) 800 N  
(e) none of these

**Problem 17.** A space probe weighs 600 N on Earth. On Planet X, it weighs 200 N. What is the gravitational acceleration on Planet X? Round your answer to the nearest 0.1 m/s$^2$. For ease of calculation, assume that $g_{\text{earth}} = 10 \text{ m/s}^2$.

(a) 0.3 m/s$^2$  
(b) 2.0 m/s$^2$  
(c) 3.3 m/s$^2$  
(d) 6.7 m/s$^2$  
(e) none of these

Apparent Weight

**Problem 18.** A block is hanging from a spring scale that is attached to the ceiling of an elevator. Under which of the following circumstances will the reading on the scale be greater than the weight of the block?

(a) The elevator is moving downward and slowing down.  
(b) The elevator is moving upward and slowing down.  
(c) The elevator is moving downward at constant speed.  
(d) The elevator is moving upward at constant speed.

**Problem 19.** A block is hanging from a spring scale that is attached to the ceiling of an elevator. Under which of the following circumstances will the reading on the scale be less than the weight of the block?

(a) The elevator is moving downward at constant speed.  
(b) The elevator is moving upward at constant speed.  
(c) The elevator is moving downward and slowing down.  
(d) The elevator is moving upward and slowing down.

**Problem 20.** A lamp with a mass of 6.0 kg is hanging from a thin cord attached to the ceiling of an elevator. When the elevator is accelerating upward at 2.0 m/s$^2$, what is the tension in the cord? For ease of calculation, assume that $g = 10 \text{ m/s}^2$. Round your answer to two significant figures.

(a) 48 N  
(b) 64 N  
(c) 72 N  
(d) 80 N  
(e) none of these
Problem 21. You are standing on a spring scale on an elevator. When the elevator is not moving, the scale registers a weight of 600 N. When the elevator starts moving, it has an downward acceleration of $2 \text{ m/s}^2$. What weight does the scale register while the elevator is accelerating downward? For ease of calculation, assume that $g = 10 \text{ m/s}^2$.

(a) 300 N  
(b) 480 N  
(c) 750 N  
(d) 1200 N  
(e) none of these

Springs

Problem 22. A spring is hanging from the ceiling. Its unstretched length is 12 cm. When a block with a mass of 6 kg is hanging from the end, it stretches to a length of 15 cm. What is the force constant of the spring? For ease of calculation, assume that $g = 10 \text{ m/s}^2$.

(a) 4 N/m  
(b) 20 N/m  
(c) 400 N/m  
(d) 2000 N/m  
(e) none of these

Problem 23. A spring is hanging from the ceiling. Its unstretched length is 15 cm. When a block with a mass of 8 kg is attached to the end, it stretches to a length of 20 cm. If you want to stretch the spring to a length of 30 cm, how much mass must you hang from it?

(a) 8 kg  
(b) 12 kg  
(c) 16 kg  
(d) 24 kg  
(e) none of these

Problem 24. (Lab Problem) A spring is hanging from the ceiling in the physics lab. When there is no weight hanging from it, the spring is 42 cm long; it has a spring constant of 8300 N/m. You hang a lead block with a mass of 87 kg from the spring, stretching it. What is the length of the spring with the weight hanging from it? Round your answer to the nearest centimeter.

(a) 10 cm  
(b) 21 cm  
(c) 32 cm  
(d) 52 cm  
(e) none of these
Problem 25. A crate with a weight of 400 N is on a frictionless slope of 20°. It is held in place by a bungee cord running parallel to the slope. If the force constant of the bungee cord is 80 N/cm, how much did it stretch after the crate was attached to it? Round your answer to the nearest 0.1 cm.

(a) 1.4 cm    (b) 1.5 cm
(c) 1.7 cm    (d) 1.9 cm
(e) none of these

Friction

Problem 26. Two blocks, one with mass $m_1$ and one with mass $m_2$, are connected by a thin horizontal rope. A second horizontal rope is attached to the block with mass $m_1$ and pulled to the left with a force whose magnitude is $P$. The coefficient of kinetic friction between each block and the floor is $\mu_k$. If the blocks move at a constant velocity, what is the tension $T$ in the rope connecting the two blocks?

(a) $m_1g\mu_k$    (b) $(m_2 + m_1)g\mu_k$
(c) $m_2g\mu_k$    (d) $(m_2 - m_1)\mu_k$
(e) none of these

Problem 27. A block with a mass of 20 kg is pulled with a horizontal force of $\vec{F}$ across a rough floor. The coefficient of friction between the floor and the block is 0.30. If the block is moving at a constant velocity, what is the magnitude of $\vec{F}$? For ease of calculation, assume that $g = 10 \text{ m/s}^2$. Round your answer to two significant figures.

(a) 6.0 N    (b) 12 N
(c) 30 N    (d) 60 N
(e) none of these
Problem 28. In your physics lab, you find the apparatus shown at right. A block with a weight of 50 N is resting on a horizontal table. A light string runs horizontally from the block, over a massless frictionless pulley, and down to a hanging bucket. The coefficient of static friction between the block and the table is \( \mu_s = 0.3 \), and the coefficient of kinetic friction between the block and the table is \( \mu_k = 0.2 \). Initially, the system does not move. You slowly add water to the bucket until the system starts moving. At this point, what is the weight \( W \) of the bucket?

(a) 10 N  (b) 15 N  (c) 20 N  (d) 50 N  (e) none of these

Problem 29. In your physics lab, you find the apparatus shown at right. A block with a weight of 40 N is resting on a horizontal table. A light string runs horizontally from the block, over a massless frictionless pulley, and down to a hanging block with a weight of 60 N. The coefficient of static friction between the first block and the table is \( \mu_s = 1/2 \), and the coefficient of kinetic friction between the block and the table is \( \mu_k = 1/4 \). After the blocks have been released to move freely, and before the hanging block has hit the floor, what is the tension \( T \) in the string?

(a) 20 N  (b) 30 N  (c) 40 N  (d) 60 N  (e) none of these

Problem 30. (Stopping Distance) The coefficient of kinetic friction between a set of tires and the road surface is \( \mu_k \). If you are driving on level pavement at a speed of \( v_0 \), and you lock up the brakes and skid to a halt, how far do you travel before you stop?

(a) \( \frac{v_0^2 \mu_k^2}{g^2} \)  (b) \( \frac{v_0^2}{\mu_k^2} \)

(c) \( \frac{v_0^2}{2\mu_k g} \)  (d) \( \frac{v_0}{\mu_k g} \)

(e) none of these
Applications of Newton’s laws to uniform circular motion

Centripetal force in the horizontal plane

Problem 31. You have left your coffee mug on the flat roof of your car. As you drive around an unbanked curve, what is the source of the centripetal force on the mug?

(a) Normal force  (b) Kinetic energy
(c) Static friction  (d) There is no centripetal force

Problem 32. A model airplane is attached to a wire so that it flies in horizontal circles around a central pylon. What is the source of the centripetal force?

(a) Tension in the wire  (b) Air resistance
(c) Inertia  (d) There is no centripetal force

Problem 33. A dead cockroach is lying on its back on the flat blade of a ceiling fan, which is slowly turning in a horizontal circle. What is the source of the centripetal force on the roach?

(a) Static friction  (b) Kinetic friction
(c) Gravity  (d) There is no centripetal force

Problem 34. A car is travelling at a constant speed clockwise around a horizontal track. Which of the diagrams below best shows the force vectors on the car at two points on the track?

Problem 35. A circular curve on a highway is designed for traffic moving at 20 m/s. The radius of the unbanked curve is 150 m. What is the minimum coefficient of friction between tires and the highway necessary to keep cars from sliding off the curve? For ease of calculation, assume that $g = 10 \text{ m/s}^2$. Round your answer to the nearest 0.01.

(a) 0.22  (b) 0.24
(c) 0.27  (d) 0.29
(e) none of these
**Problem 36. (Similarity problem)** A car travelling at a speed of $V$ goes around an unbanked curve with a radius of $R$. The centripetal force that keeps it on the road is the frictional force $F$ between the road and the tires. A few miles later, the car comes to another curve, this one with radius $R/2$, and tries to go around the curve at the same speed. What must the frictional force $f_s$ be in order to keep the car on the road?

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

**Problem 37. (Similarity Problem)** An object with a mass of $m$ is on a frictionless horizontal surface. The object is attached to a massless horizontal rod with length $r_1$ whose other end is attached to a pivot fixed in the surface; the object is then set to moving in a horizontal circle at a constant speed $v_1$. Under these circumstances, the tension in the rod is $T_1$. If the speed of the object is doubled to a constant $v_2 = 2v_1$, and the length of the rod is increased to $r_2 = 4r_1$, what will be the tension in the rod $T_2$?

(a) $T_1$  
(b) $\sqrt{2}T_1$  
(c) $2T_1$  
(d) $4T_1$  
(e) none of these

**Centripetal force in the vertical plane**

**Problem 38.** A Ferris wheel has a radius of 25 m. At its maximum speed, the seats are moving at 9 m/s. A dog is sitting on a spring scale on one of the seats on the wheel. When the wheel is not moving, the scale registers 240 N. When the wheel is turning at its maximum speed, what weight does the scale register at the lowest point of the circular path of the Ferris wheel (i.e., at the bottom of the wheel)? For ease of calculation, assume that $g = 10 \text{ m/s}^2$. Round your answer to the nearest newton.

(a) 127 N  
(b) 233 N  
(c) 318 N  
(d) 419 N  
(e) None of these
Problem 39. A block with mass $M$ is attached to the end of a massless rigid rod and whirled at a constant speed in a vertical circle with radius $R$. At the bottom of the circle, the tension in the rod is equal to three times the weight of the block. What is the speed of the block?
(a) $\sqrt{2gR}$  
(b) $\sqrt{3gR}$  
(c) $2\sqrt{gR}$  
(d) $3\sqrt{gR}$  
(e) none of these

Force of gravitational attraction

Problem 40. An astronaut with a mass of 80 kg is standing on the surface of a planet whose radius is $1.2 \times 10^6$ m and whose mass is $4.5 \times 10^{22}$ kg. What is the astronaut’s weight on the planet? Round your answer to the nearest 10 N.
(a) 170 N  
(b) 180 N  
(c) 200 N  
(d) 220 N  
(e) none of these

Problem 41. An unmanned space probe has a mass of 60 kg. It is sent to the surface of a planet with a radius of $2 \times 10^7$ m and a mass of $5 \times 10^{26}$ kg. What is the probe’s weight on the planet? Round your answer to the nearest 100 N. For ease of calculation, assume that $G = \frac{2}{3} \times 10^{-10}$ N m$^2$/kg$^2$.
(a) 3600 N  
(b) 4100 N  
(c) 4500 N  
(d) 5000 N  
(e) none of these

Orbits

Problem 42. A space probe is in circular orbit around Planet X, at a distance of $4.0 \times 10^7$ m from the planet’s center. The probe’s orbital speed is 1200 m/s. What is the mass of Planet X? Round your answer to two significant figures.
(a) $8.6 \times 10^{23}$ kg  
(b) $9.5 \times 10^{23}$ kg  
(c) $1.0 \times 10^{24}$ kg  
(d) $1.1 \times 10^{24}$ kg  
(e) none of these

Problem 43. A small moon is in circular orbit around Planet X, at a distance of $3 \times 10^8$ m from the planet’s center. The moon’s orbital speed is 200 m/s. What is the mass of Planet X? Round your answer to two significant figures. For ease of calculation, assume that $G = \frac{2}{3} \times 10^{-10}$ N m$^2$/kg$^2$.
(a) $1.6 \times 10^{23}$ kg  
(b) $1.8 \times 10^{23}$ kg  
(c) $2.0 \times 10^{23}$ kg  
(d) $2.2 \times 10^{23}$ kg  
(e) none of these
Applications of Newton’s laws to rotating bodies

Moment of inertia

Problem 44. A physics instructor has a mass of 90 kg. His wife has a mass of 60 kg. The two are riding together on a merry-go-round with two concentric circles of wooden horses. In which of the following situations is the system’s moment of inertia the smallest?

(a) Both sit together one on one of the outer horses
(b) Both sit on outer horses, on opposite sides of the merry-go-round
(c) She sits on one of the outer horses; he sits on the inner horse next to her
(d) He sits on one of the outer horses; she sits on an inner horse on the opposite side

Problem 45. A flywheel consists of a solid iron disc with two holes drilled through it, turning on a shaft through its center. In which of the following arrangements of holes is the moment of inertia the largest?

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Problem 46. (Similarity Problem) A system consists of a massless turntable with a lead block with mass \(m_1\) attached at a distance of \(r_1\) from the center. A second system has the same moment of inertia, but uses a block with mass \(m_2 = 2m_1\). At what distance \(r_2\) is this block attached?

(a) \(r_1/4\)  
(b) \(r_1/2\)  
(c) \(r_1/\sqrt{2}\)  
(d) \(r_1\)  
(e) none of these

Torque

Problem 47. A massless horizontal pole projects a distance \(r_1 = 1.6\) m from the side of a building. It is held up by a cable running from the side of the building to the end of the pole, making an angle of \(\theta = 35^\circ\) to the horizontal. A sign weighing \(w = 30\) N hangs from the pole a distance \(r_2 = 1.5\) m out from the building. What is the tension \(T\) in the cable? Round your answer to two significant figures.

(a) 28 N  
(b) 34 N  
(c) 39 N  
(d) 49 N  
(e) None of these
Problem 48. A teeter-totter consists of a massless board pivoting on a fulcrum. A physics instructor weighing $w_1 = 800$ N sits 1.5 m from the fulcrum. A physics student weighing $w_2 = 600$ N sits on the opposite side. How far from the fulcrum must the student sit to balance the instructor’s torque? Round your answer to two significant figures.

(a) 1.6 m  
(b) 1.8 m  
(c) 2.0 m  
(d) 2.2 m  
(e) none of these

Problem 49. A flywheel has a radius of 60 cm and a moment of inertia of 150 kg·m². A belt around the rim of the wheel imparts a force of 80 N. What is the flywheel’s angular acceleration? Round your answer to two significant figures.

(a) 0.29 rad/s²  
(b) 0.32 rad/s²  
(c) 0.35 rad/s²  
(d) 0.39 rad/s²  
(e) none of these

Problem 50. A windmill has a moment of inertia of 5.0 kg·m². When the wind begins to blow, it accelerates at 0.40 rad/s². What is the torque on the windmill? Round your answer to two significant figures.

(a) 0.80 N·m  
(b) 2.0 N·m  
(c) 5.0 N·m  
(d) 13 N·m  
(e) none of these