Practice Problems For Chapter 10

The problems and solutions that follow were designed by students. Although I have checked them, there are very possibly a few errors here and there. If you notice a mistake and turn in a typed correction, you will receive two extra homework points. You may also write new homework problems to add to any chapter and receive between 2 and 5 homework points per problem (see syllabus for details.) Please note: since these problems were written by students, the teacher takes no responsibility for errors – in other words, if there is a mistake and you make the same mistake on a test, you will not get credit for that mistake.

In the problems below, I have highlighted what I feel are the best problems to study prior to tests. The other problems are all ok, but they tend to be very easy problems or repeats of homework problems with slight variations. You may want to start with a few of the regular problems as warm up and then move on to the highlighted problems.

Chapter 10 Problems

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1. Which has more kinetic energy, a cyclist (bike and rider= 65 kg) at 45 mph or a 18 wheeler (5000 kg) at 2 mph?

   John Stevenson ‘07

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2. Mr. Laba is a very goofy person. One day, he found a bouncy ball that he had once won in 4^{th} grade. He knew now that he could calculate the energy and the height of the bounces, so in a closed, isolated system where energy is conserved, what is the height of the bounce of a bouncy ball if it is dropped from 10 meters, and if it contains only 70% of the initial energy in its first bounce? How high would it go on its second bounce if it contained only 63% of the energy on the second bounce? (mass=20g)

   Amish Bhatia ‘07

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3. Stewart gets to do the coin flip at the Super Bowl. If the coin has a mass of 5 g and he flips it with a Vi of 4 m/s what is the potential energy at the top?

   Karl Thumm ‘07

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4. Which has more kinetic energy, a Hummer H1 at 60 mph (weight 7847 lbs) or a Ariel Atom (1005.5 lbs) at 180 mph?

   John Stevenson ‘07

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5. If the specific heat of Dr. Pepper is about 5 (guess/ approximation), how much energy is needed to heat a can of DP (355 mL, mass 390g) to 180 deg from room temperature (70 deg)?

   John Stevenson ‘07

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6. Which has more kinetic energy, a bicycle (mass: 15kg) at 25 mph, or a Hummer H1 (7842 lbs) at 5 mph?

   John Stevenson ‘07

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7. Moritz is running with a velocity of 10m/s towards the German chocolate he dropped in the street. If he has a mass of 80kg, what is Moritz’s kinetic energy?

   Annie Matusewicz ‘07

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8. One of King Laba’s friends is doing pull ups in the king’s golden gym. As his palms produce some perspiration, his hands begin to slip on the 24 karat gold. If the friend has a mass of 80kg and the pull up bar is 50m above the ground (Yes,

King Laba likes to live dangerously), how much potential energy does the friend have before letting go of the pole?
b. How fast is King Laba's not-so-strong friend going when he reaches the surface of the Cherry Kool-Aid pool below?

Annie Matusewicz '07

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9. How much heat is required to raise the temperature of 50 mL of water 15 degrees?

John Stevenson '07

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10. A long-haul trucker says that his truck (mass 2000 kg) at 20m/sec has more kinetic energy than Mr. Laba's Labamobile (mass 1200 kg) at 50m/sec. Is the trucker correct?

John Stevenson '07

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11. -5000 J are needed to push a large button that triggers a bouncy ball (24g) straight up. The trigger projects the bouncy ball directly upward at 230 m/s. If Sandra drops an 80 g weight from 10 meters how much energy would be exerted? Would that be enough to push the button? If so how high would the bouncy ball go?

Karl Thumm '07

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12. Mr. Laba decides it would be fun to use his new spring to shoot a projectile at a student. The spring is compressed .015 meters, and the projectile weighs 10 grams. If the student is 2.6 meters away, at the same level as the gun, at what angle must Mr. Laba aim the spring-gun to hit him? ($k=1200\ kg/sec^2$, ignore friction/air resistance)

Moritz Sudhof '07

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13. Arnold Schwarzenegger challenges Mr. Laba to a duel. They will punch each other in the shoulder. Arnold's punch is 20 m/s, and the mass put behind it is a raging 100 kg. Mr. Laba has spent years studying Martial Arts under master Han Ku Ping in China. He is now a lightning fast fighter, so he punches at 60 m/s, but with only 15 kg of mass. Whoever punches harder wins. Who wins? Support your answer.

Moritz Sudhof '07

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14. One day, Mr. Laba randomly quits his job as a Physics teacher and decides to build a roller coaster. Mr. Laba is the Willy Wonka of roller coasters—he wants

to make the biggest roller coaster ever, and he has figured out how to make frictionless tracks. The roller coaster starts off on a huge hump, and then just rolls down. If he wants the cart to be going the speed of light at the bottom of he slope, how high should he make his roller coaster? (speed of light = 3.0×10^8 m/s)

Moritz Sudhof ‘07

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15. When a physics student is not paying attention, Mr. Laba is angry. In order to intimidate the student, he therefore turns around and picks up Princess, his pet hippopotamus, and hurls her in the air. Princess weighs 1,000 kg, and Mr. Laba tosses her up with a velocity of 9 m/s. (Ignore air resistance)
A. How much energy is involved in the hippopotamus-throwing?
B. Using energy considerations, how far up does Princess rise before falling back to the ground (assume it she was thrown straight up in the air)?

Moritz Sudhof ‘07

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16. Arnold Schwarzenegger jumps on a big spring from a height of 160 m. The spring compresses 5.3 m and shoots him back up with a velocity of 45 m/s. What is the efficiency of the spring?
(Schwarzenegger weighs 115 kg)

Moritz Sudhof ‘07

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17. You are traveling down the road with the great Tom Brady when all of a sudden your car’s accelerator jams and you switch it to neutral. Up ahead is a hill that rises 17 meters, and at the very top lies a bed of nails that will no doubt deflate all your tires. Unfortunately, your brakes do not work and your car never loses any speed to friction. If under the influence of Tom Brady, you were traveling at 18 m/s, would you pop your tires?

John Wheeler (class of 2008)

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18. Running at full speed, you leap off the ground and hit a wall head on. If you have a mass of 70 kg and reach a speed of 1.15 m/s right before impact, will you crack open your scull? (It takes over 37.63 J to crack you cranium)

John Wheeler (class of 2008)

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19. The quarterback fades back and throws a ball fifty-five yards to the end zone. The ball was released traveling 24 m/s and was caught traveling 14 m/s. The ball was caught and thrown at shoulder level. If 16.3 J were lost to friction, how heavy was the ball?

John Wheeler (class of 2008)

20. Pete and Repeat were sitting on a fence (3m high), if Pete (75kg) fell off
    a. With how much energy did he hit the ground?

    John Wheeler (class of 2008)

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21. In a recent study, a new brand of cars produced by general motors are built with 76% efficient engines. If these cars go 55 m/s after 10 seconds, how fast would they be going in 10 seconds with 100 % efficient engines? (the cars have a mass of 8600 kg)

    John Wheeler (class of 2008)

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22. In a virtual monster truck game, there is a mode called collision. In this mode, two trucks hit each other head on and the truck with the most energy wins. If Connor is using a truck that weighs a measly 26 kg and Evan is using a 8000 kg monster truck that travels at 16 m/s, how fast will Connor's truck have to be going at collision in order to defeat Evan's car?

    John Wheeler (class of 2008)

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23. What is the kinetic energy of a Mongolian racing snail (.35 kg), if it's traveling at a constant 23m/s?

    Mitchell Williams '08

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24. What is the kinetic energy of a salmon swimming upstream (2.4kg) if the salmon can travel at 1.3 m/s?

    Mitchell Williams '08

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25. What is the change in potential energy of a 52 kg freshman who was being held 2 meters above the ground (by a senior because the freshman dared to look him in the eyes) if the freshman is lifted so his height is now 2.3 meters?

    Mitchell Williams '08

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26. A 2kg block is raised 12 meters vertically. What is its change in potential energy?

    Mitchell Williams '08

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27. A swallow carries a 3kg coconut. If the swallow takes off from the ground and travels 35meters at a 30^{o} angle, what is the change in potential energy of the coconut? Is the swallow African or European?

    Mitchell Williams '08

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28. Dan has taken awkward stain cat and decided to throw him up onto the balcony of the physics room. If awkward stain cat has a mass of 250g and the height of the balcony is approximately 4m what would be awkward stain cat's potential energy change?

    Russell Bicknell (08)

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29. A frictionless MarbleWorks set is put together during your free time. You set your marble at the top of the set, and then release it. What velocity will the marble have at the end of the course, if the course is 3 meters high? If our presupposition of no friction are incorrect, and the marble comes out at 3 m/s, what percent of energy was lost to friction?

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30. If a 50 kg piñata is dropped from height of 5 meters, and a 100% efficient converter puts that energy into a microwave with a power of 200 watts, how long would it run? If it heated a 200 g cup of macaroni (specific heat 240 J/g Cº), how much hotter would it get?

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31. Yvonne sees a light at the end of the tunnel. If the lightbulb she sees is able to burn at 90 watts for three minutes, and she is able to harness that energy to move her 60 kg self out of the tunnel, how fast will she be able to move? What does this say about her chances of moving out of the tunnel?

    Franci Rooney 08

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32. Rodney wants to stop his spankin new brakeless car. If he was going 22 m/s and stopped by rolling up a nearby hill, how much higher up will he be when his car stops? What about when it is still going 5 m/s?

    Franci Rooney ('08)

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33. A spring (k=650 N/m) fires a 320 gram ball after being compressed .9 centimeters. Another spring (k=790 N/m) fires a 600 gram ball after being compress 1.3 centimeters. Which ball will cross the finish line first if the line is 4.5 meters from where both balls are launched. Assume the table is frictionless.

Bethany Berg (class of 2011)

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34. Using the information above, how long will it take the winning ball to reach the finish line? The losing ball? Still assume the table is frictionless.

Bethany Berg (class of 2011)

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35. If the table were to have friction, and the coefficient of friction were .43, how far would the winning ball travel before it came to a stop?

Bethany Berg (class of 2011)

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36. A spring is loaded with a 200 gram ball and is compressed 31 centimeters. It’s set at an angle of 41 degrees to the horizontal and he knows that it will land 45 meters away on the same level. What is the spring’s constant?

Bethany Berg (class of 2011)

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37. If a rubber-band ball is dropped from 8 meters off the ground and bounces back up to 6.5 meters, how efficient was the collision with the ground in terms of velocity?

Bethany Berg (class of 2011)

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38. A new type of zirconium, which has an atomic number of 40, has 250 neutrons and an atomic mass of 294 amu. What is the mass defect of the new zirconium?

Bethany Berg (class of 2011)

<u>Chapter 10 Answers</u>

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1. *Work:*

$T=1/2mv^2$
$T=1/2(65)(20.11)^2$
T=26000
$T=1/2(5000)(.89)^2$
T=3960.5
Answer: The bike

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2. Ti = Tf +U

Tf = -mgh
Tf = (.02kg)(9.8)(10)
1.96(.7) = Tf(.7)
1.372 = -mgh
Bounce 1: H = 7m
1.372(.63) = -mgh
Bounce 2: H = 4.41m

3.

-MGH = PE

5(9.8)(H) = PE

$Vf^2 = Vi^2 + 2\ a\Delta x$
$0 = 4^2 + 2\ (-9.8)\Delta x$
$0 = 14 + -19.6\Delta x$
$-14 = -19.6\Delta x$
$\Delta x = .714$ m

-5(-9.8)(.714) = PE
35 N = PE

4.

Work:
$K=(1/2)mv^2$
$K(hummer)=(1/2)(3559)(26.8224)^2=1280245.512$ J
$K(atom)=(1/2)(456)(75.9968)^2= 1317068.338$ J
Answer: the Ariel Atom

5.

Work:

$H=mc\Delta T$

$H=(390*5*(180-70)$

Answer: H=274500 J

6.

Work:

$K=(1/2)mv^2$

$K(hummer)=(1/2)(3557.071)(2.235)^2= 8884.184993\ J$

$K(bike)=(1/2)(15)(11.176)^2= 936.77232\ J$

Answer: the Hummer

7.

Energy = ½ mv^2

½ * 80 * 10^2

Energy = 4000J

8.

Potential Energy = -mgh

Energy = -80*9.8*50

Potential Energy = 39200J

$v^2 = 2*a* \Delta x$

$v^2 = 2*9.8*50$

$v^2 = 980$

v = 31.3m/s

9.

Work/ Answer

$H=mc\Delta T$

H=50(4.18)15

Answer: H=3135J

10.

Work/ Answer:

$T=(1/2)mv^2$

$T_{truck}=(1/2)2000(20^2)$

$T_{truck}= 400000$ J

$T_{Laba}=(1/2)1200(50^2)$

$T_{Laba}= 1500000$ J

Answer: the trucker is incorrect

11.

-MGH
-(0.080)(9.8)(-10)
7.840 J

vi= 230 m/s

½ mv^2
(0.012) (230^2)
634.800

634800 = -MGH
634800= -(0.024) (-9.8) h
634800= 235.2 h
h= 2698.7

12.

$\Delta U_{sp} = (1/2)k\Delta x^2$
$\Delta U_{sp} = (1/2)(1200)(.015^2)$
$\Delta U_{sp} = .135$ J

$T = (1/2)mv^2$
$.135 = (1/2)(.01)v^2$
$27 = v^2$
v = 5.2 m/s

$\Delta x = -(V^2 \sin 2\vartheta)/g$
$2.6 = (5.2^2 \sin 2\vartheta)/9.8$
$.9423 = \sin 2\vartheta$
$\arcsin(.9423) = 2\vartheta$
$70.44 = 2\vartheta$
$\vartheta = 35.22$

13.

Mr. Laba wins.
$T = (1/2)mv^2$
Therefore, speed matters more than mass. Mr. Laba’s got the speed.

$T = (1/2)(100)(20^2)$
T = 20000 J

$T = (1/2)(15)(60^2)$

T = 27000 J

Mr. Laba smacks up Schwarzenegger.

14.

$\Delta U = -mgh$
$T = (1/2)mv^2$
$mgh = (1/2)mv^2$
$9.8h = (1/2)(3.0 \times 10^8 \text{ m/s})$
h = 15306122.45 m

$h = 1.53 \times 10^7$ m

15.

A.
$T = (1/2)mv^2$
T = (1/2)(1000)(81)
40500 J

B.
$\Delta U = -mgh$
$T = (1/2)mv^2$
$(1/2)mv^2 = mgh$
$(1/2)9^2 = (9.8)h$
h = 4.13 m

16.

$\Delta U = -mgh$
$\Delta U = (115)(9.8)(160)$
$\Delta U = 180320$ J

$T = (1/2)mv^2$
$T = (1/2)(115)(45^2)$
T = 116437.5 J

Eff = out/in x 100
Eff = 116437.5/180320 x 100
Eff = 64.6%

17.

$T_i = T_f + \Delta U$

$0.5mv^2 = mgh$

(18)(18)/(2)(9.8)= h

h= 16.53m Since this is below 17 meters, you will not make it to the top of the hill, but will instead begin to fall backwards once you get close.

18.

$T_i = T_f + \Delta U + \Delta H + \Delta E_d$

$0.5mv^2 = \Delta E_d$

$(.5)(70)(1.15)^2 = \Delta E_d$

$\Delta E_d = 46.29$ J

Ouch

19.

$T_i = T_f + \Delta U + \Delta H + \Delta E_d$

$0.5mv_i^2 – 0.5mv_f^2 = \Delta E_d$

0.5m(24 -14) = 16.3

M = 3.26 kg

20.

$T_f = \Delta U$

$T_f = mgh$

$T_f = (75)(-9.8)(-3)$

$T_f = 2205$ J

21.

T_f = (.5)(m)(v^2)

T_f = (.5)(8600)(55^2)

T_f = 13007500 J

T_f = 13007500 (100 / 76)

17115131.58 = (.5)(8600)(v^2)

V= 63.09 m/s

22.

T_E = (.5)(8000)(16)(16)

T_E = 1024000 J

1024000 = (.5)(26)(v^2)

V= 280.66 m/s (Connor needs to go at least this fast in order to upset Evan)

23.

$T=(1/2)mv^2$
$T=(1/2)(.35)(23)^2$
T=92.575 J

24.

$T=(1/2)mv^2$
$T=(1/2)(2.4)(1.3)^2$
T=2.028 J

25.

U=-mgh
U_1=-(52)(-9.8)(2)
U_1=1019.2 J

U=-mgh
U_2=(52)(-9.8)(2.3)
U_2=1172.08 J

U_2-U_1= change in potential energy
1172.08-1019.2=152.88J

26.

$U=-mgh$
$U=-2(-9.8)(12)$
$U=235.2$ J

27.
$U=-mgh$
$U=-(3)(-9.8)(35\sin(30))$
$U=514.5$ J

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28. Answer:
$\Delta U = -mgh$
$\Delta U = -(0.25)(-9.8)(4)$
$\boxed{\Delta U = 9.8J}$

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29. Answer:
$m * 9.8 * 3 = 29.4m = mv^2$
$v = 5.4$
70% efficient

30.
Mgh = 2450 J, divided by 200 = 12.5 seconds
$Mc\Delta t = 200\ (240)\ (t)$, $t = .05^{o}$

Franci Rooney 08

31.
90 Joules/second = x Joules/180 seconds
16200 Joules
$T = ½mv^2$
$16200 = ½\ 60\ v^2$
v = 23 m/s
she will be tearing out of that tunnel.

32.
$mv^2/2 = mgh$
$22^2/2 = 9.8\ h$
h = 24.6 meters higher
$22^2/2 = 5/2 + gh$
second h = 24.4 meters.

33.

$\frac{1}{2} k\Delta x^2 = \frac{1}{2} mv^2$

Spring 1:

$.5(650)(.009)^2 = .5(.32)v^2$

$.026 = .16v^2$

$v^2=.16$

$v= .4$ m/s

Spring 2:

$\frac{1}{2} k\Delta x^2 = \frac{1}{2} mv^2$

$.5(790)(.013)^2 = .5(.6)v^2$

$.067 = .3v^2$

$.223 = v^2$

$v = .473$ m/s

Therefore, the ball launched from the second spring will reach the finish line first.

34.

Winning ball:

$\Delta x = V_x t$

$4.5 = .473t$

$t=9.51$ seconds

losing ball:

$\Delta x = V_x t$

$4.5 = .4t$

$t = 11.25$ seconds

35.

$F = ma$

$-F_F= .6\ a$

$F_f = .43(.6)(9.8)$

$F_f= 2.53$ Newtons

$-2.53 = .6a$

$a = 4.214\ m/s^2$

$V_f^2 = V_i^2 + 2a\Delta x$

$0 = .473^2 + 2(-2.53)\ \Delta x$

$\Delta x = .044$ meters

36.

$\Delta x = -(V^2 \sin 2\theta)/g$
$45 = -(V^2 \sin 2(41))/9.8$
$V^2 = 445.33$
$V = 21.1$ m/s

$½ k\Delta x^2 = ½ mv^2$
$.5(k)(.31^2) = .5(.2)(21.1^2)$
$k = 926.6$ N/m

37

$V_f^2 = V_i^2 + 2a\Delta x$
$V_f^2 = 0 + 2(9.8)8$
$V_f = 12.52$ m/s

$V_f^2 = V_i^2 + 2a\Delta x$
$0 = V_i^2 + 2(-9.8)(6.5)$
$V_i^2 = 11.28$ m/s

11.28/12.52 = .9015 x 100 = 90.15 % efficient

38.

40 protons (1.0073) = 40.292
250 neutrons (1.0087) = 252.175
total = 40.292 + 252.175 = 292.467 amu
mass defect = 294 – 292.467 = **1.533 amu**

$1.533(1.66 \times 10^{-27}) = 2.54 \times 10^{-27}$
binding energy = $2.54 \times 10^{-27} (3 \times 10^{8})$ = **7.63×10^{-19} Joules**