Chapter 6

A Good Thing To Know

Work and Energy are interchangeable.
Work = Force x distance
Gravitational Potential Energy = PE = U_g = mgh
Spring Potential Energy = PE_{sp} = U_{sp} = ½ kx^2
Kinetic Energy = ½ mv^2
Power = $\frac{Work}{time}$

1. Energy and work are interchangeable. The maximum work = PE_{max}. PE = mgh.

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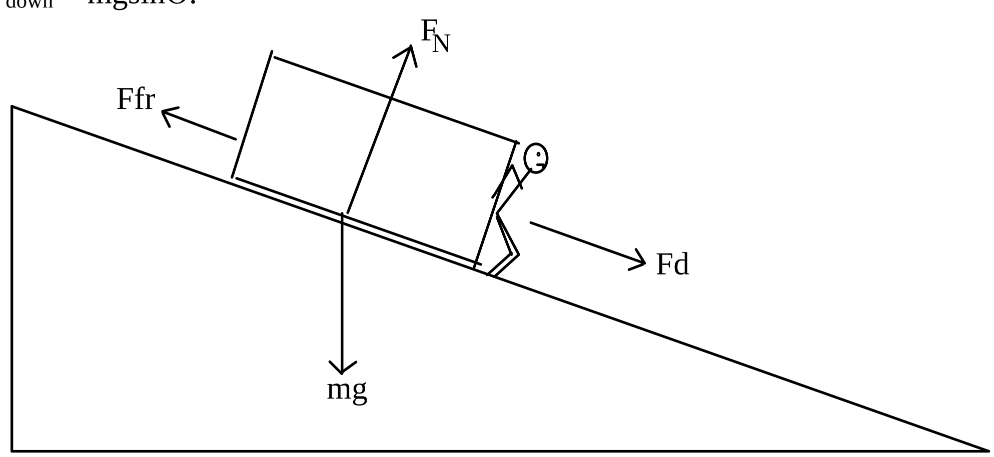
3. a) v = constant, a = 0, so the force necessary to push = F_{fr} = mgμ and W = F x d.
   b) v = constant, a = 0 so the force necessary to lift = mg. W = mgd

4. If v = constant and a = 0, then F_{ret} x d = W. Solve for F_{ret}.

5. F = ma. To find acceleration, list your variables and choose from VAT, VAX or VATX to solve for acceleration.

8. a) The piano is not accelerating so F_{res} = = $F_{down} - F_{man} - F_{fr} = 0$. F_{fr} = mgcosΘμ and F_{down} = mgsinΘ.



b) $W_{man} = F_{man}d$ (because Fres = 0)
c) $W_{fr} = F_{fr}d$ (because Fres = 0)
d) Wg = F_{down} x d (because Fres = 0)
e) Wnet = $W_{man} + W_{fr}$ + Wg. All down (to the right) forces are (+) and all up (to the left) forces are (-)

9. This is an elevator-going-up problem. (See the homework hint for problem 12 chapter 4).
   a) Find F(up)
   b) W(up) = F(up) x d
   Use the symbols given instead of numbers.

12. a) Work = are under the curve of a Force vs. Distance graph.
   b) Area above the x-axis is (+). Area under the x-axis is (-). Find the area under both curves and add them algebraically.

15. KE = ½ mv^2. You are given mass and energy. Find velocity.

18. The work to stop the car is equal to its kinetic energy. You are given mass and velocity. Convert velocity to m/s and solve for KE and, therefore, work.

19. The work done on the arrow = Fd and is converted to KE once it is fired. Fd = ½ mv^2. Be sure to convert cm to meters and solve for v.

20. KE of the ball = work done by the glove to stop it. KE = ½ mv^2. W == F x d. Combine equations and solve for d.

22. The work to stop the car and overcome the car's KE was done by friction. W(stop) = KE. W = F x d = mad. Combine these equations and solve for v.

24. The work done on the rock = PE gained once it is at the top of the trajectory. Work = Force x distance = $PE_{(top)}$. The only force on the rock at the top = gravity.

25. Convert g's to acceleration by multiplying by 9.8.
   a) This is an elevator-going-up problem. Solve for F_T.
   b) The net work done to lift the load = the net force x the height, or ma x h.
   c) The net work done by the cable = F_T x d. It is (+) because it is going up.
   d) The net work done by gravity is mgd. It is (-) because it is directed down.
   e) The net work to lift the load = the KE it will have when it reaches the 21.0 meters. Use the answer for net work (part b) and set that equal to ½ mv^2 and solve for v.

26. PE of a spring = ½ kx^2. You are given the spring constant and energy. Solve for the stretch distance.

28. ΔPE = Δmgh. Since mg remains constant, ΔPE = mgΔh

31. a) ΔPE = Δmgh   b) W = ΔPE   c) Think about it!

32. According to Hooke's Law, F = -kx. If the weight just hangs on the spring (and doesn't bounce) F = gravity and x = stretch distance. Find x in terms of the ruler.

33. KE gets turned into PE. Set the 2 equations equal and solve for h.

34. Find the vertical component of the acceleration using the angle given. The skier starts from rest, and you are given the vertical distance. Choose from VAT, VAX or VATX and solve for final velocity.

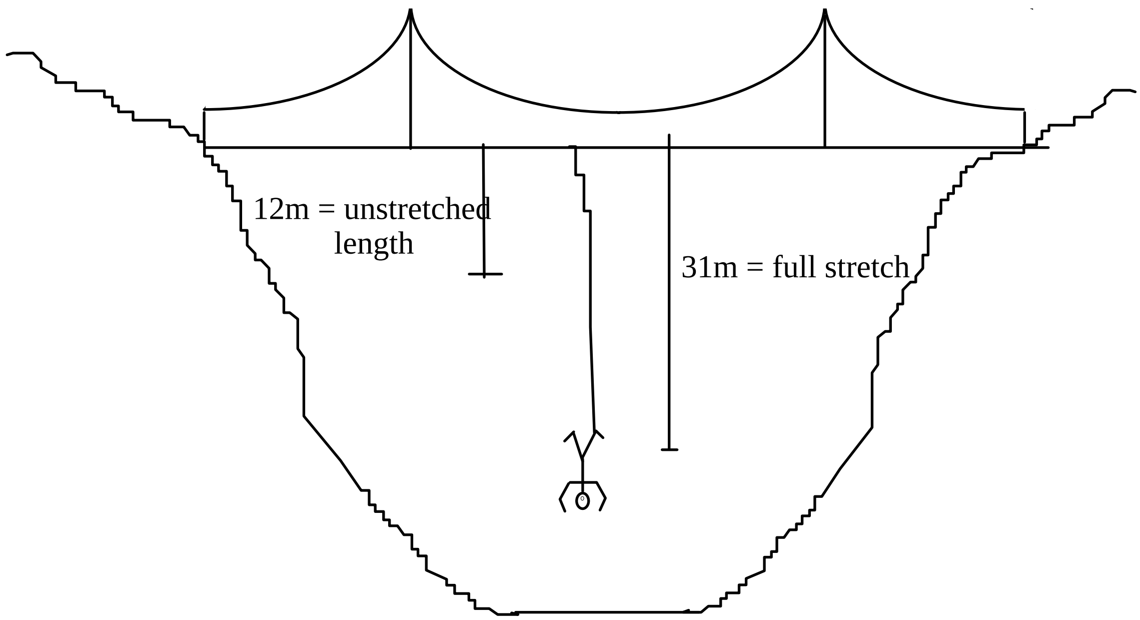
36. KE is converted into PE as well as KE as the jumper crosses the bar. Masses will cancel out. You are given the height of the jump and the speed as he crosses the bar (v_2). Solve for the initial velocity of the jumper (v_1).

37. Both the PE and KE of the jumper at the top of the platform will be converted to KE(max) as he hits the trampoline.
    a) KE(top) + PE(top) = KE(trampoline). You are given the jumper's mass, his initial velocity at the top and the distance he falls. Substitute variables and solve for v at the trampoline.
    b) The KE of the jumper at the trampoline will be converted to PE of the spring once the trampoline stretches to its maximum. Set PE(sp) = KE(tramp) and solve for k.

39. The spring is being compressed vertically. You're given the spring constant, the compression distance and the mass of the ball.
    a) The Spring Potential Energy will give the ball kinetic energy. Use this information to solve for the velocity of the ball.
    b) Now you know the initial velocity of the ball, that it stops at the top of the trajectory and that gravity stops it. Use this to calculate the vertical height.

40. The potential energy at the release point must equal both the potential and kinetic energies at the top of the loop. Let the 2x the radius of the loop be the height of the potential energy at the top of the loop. Express the velocity at the top of the loop in terms of gravity and radius and solve for h (the height of the launch point). To get the velocity of the car at the top of the loop, remember that at minimum velocity, gravity is the only thing providing the centripetal force at the top of the loop. Set centripetal force equal to gravitational force and solve for v.

42. a) Calculate the total length that the cord stretches. The TE of the jumper will convert 1st to KE and then to PE of the spring.
PE(top) = KE(max) = PE(sp). Set equations equal and solve for k.



b) The maximum acceleration is when the jumper is at the very bottom of bungee stretch. That makes this an elevator-going-up problem. Fres = F_T – mg. Solve for a. F_T is the upward restoring force of the spring, = kx.

43. TE(top) = TE(bottom)   TE(top) = PE(top) + KE(top).
TE(bottom) = all KE because h = 0
Using these equations, derive a general equation for any velocity *v* at height, *h*. Substitute variables and solve for v(bottom). You'll have to do this problem 3 times; once with h at bottom = 0m, once with h = 28m and once with h = 15 m.

48. PE(top) is converted to KE(bottom) + Wfr along the way. Set PE(top) = the sum of KE(bottom) + Wfr and solve for Wfr because the work done by friction is what is converted into heat.

49. a) The force down the slope = ma = force down an incline minus the frictional force along the incline that resists it. Calculate the acceleration down the slope. Now you have initial velocity, distance and acceleration. Choose from VAT, VAX, or VATX and calculate final velocity.
OR Use Conservation of energy. TE(top) = KE(bottom) + W(fr)
b) Once you have velocity at the bottom use: KE(bottom) = W(stop) = F(fr) x distance.

50. a) Use conservation of energy: PE(top) = KE(bottom)
b) KE when it bounces = PE when it reaches 1.5m
c) When energy is lost, where does it usually go?

51. Example 4-21 page 94 outlines equations for calculating forces down inclines and forces due to friction on inclines.
a) The resultant acceleration is due to the acceleration down the slope minus the resistance due to friction.
b) Find the kinetic energy the ski had at the bottom of the slope and set that equal to the work done by friction to stop it. Solve for distance.

53. TE(top) = mgh + ½ mv^2. TE (top) = KE(bottom) + Work done by friction.
Work done by friction = F_{fr} x distance

54. TE(bottom) = TE(top)   TE(bottom) = all KE (because h = 0).
TE(top) = PE(top) + KE(top) + Wfr. Set TE(bottom) = TE(top) and (with algebraic wizardry) solve for μ. Don't forget, Ffr on a slant = mgcosΘμ. Wfr = Ffr x d.

56. The spring potential energy will become kinetic energy of the block at the maximum extension of the spring. Use this information to calculate the maximum velocity of the block as it leaves the spring. (The spring is "very light" so it has no mass for this problem). This is the maximum velocity for the oscillating spring. Use this information to solve for the maximum amplitude of the spring. That will be the maximum stretch distance beyond equilibrium.

58. Power = Work per time or $P = \frac{W}{t}$. You are given power, mass and height. Find the potential energy (that will be equal to the work done to lift the piano) and solve for time.

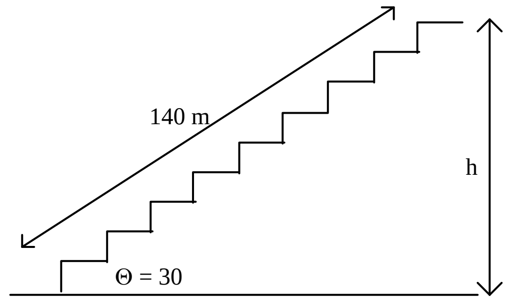
60. Power = $\frac{Work}{time}$ = Force x velocity

63. The first sentence gives enough information to solve for F_{fr}. (F = ma. List your variables and choose from VAT, VAX or VATX to solve for a). To travel at a constant velocity, you only need enough force to overcome friction. If you know force and velocity, you can find power.

64. Power = $\frac{Work}{time}$. Convert hp to Joules and hours to seconds. Then solve for work.

65. $Power = \frac{Work}{time}$. You're given the time. The work to accelerate the shot-put is equal to the kinetic energy it had once it was released.

67. Find h using trigonometry and then
calculate the work to climb the stairs. Pt = W.



69. Power = $\frac{Work}{time}$ = Force x velocity. In this case, you have to add the force due to gravity down the incline, plus the frictional forces impeding the motion of the car. Change hp to Joules and solve for the angle, Θ.

72. Convert km/hr to m/s and cm to m. The KE of the car will convert to PE(sp) (the bumper). Set these equations equal and solve for k.

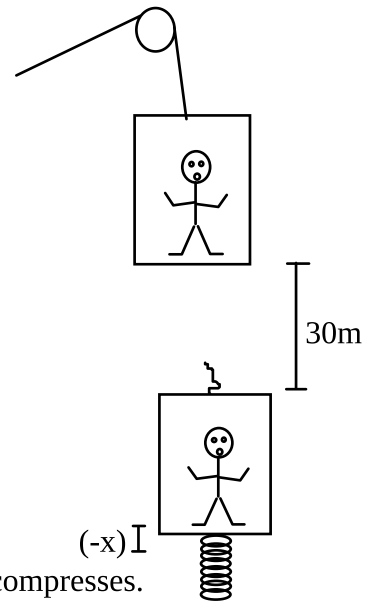
74. KE is converted into PE as well as KE as the jumper crosses the bar. Masses will cancel out. You are given the height of the jump and the speed as he crosses the bar (v_2). Solve for the initial velocity of the jumper (v_1).

75. a) Same as problem 40.
b) Use energy conservation to solve for the velocity at the bottom of the track. Use that to calculate the centripetal force at the bottom of the track. The Fc at the bottom is also the resultant force, which is the sum of the normal force (+) and weight (-).
c) Use energy conservation to solve for the velocity at the top of the loop. The Fc at the top is the sum of the normal force (which is now down) and mg (also down).
d) There is no Fc on the horizontal section of the track and vertical components cancel.

76. a) W(snow) = KE of pilot when he hit.
b) W(snow) = F x d. Solve for F.
c) W = ΔKE. Find the KE that the pilot should have had if he had fallen from 370 m without air friction to slow him down. Subtract the actual KE he had when he hit the snow. The difference is the work done by air friction to slow him down.

78. a) Too easy. b) Pt = W c) Rate of energy = power. Set up a simple proportion. If your answer to (b) is 15%, what will equal 100%?

79. The spring has a significant compression so you can't solve this one like problem 39, although if you do, the answer won't be very different from the one obtained as follows:



It will take 3 steps to properly solve this problem.

a) Wg = PE (top)

b) PE(top) becomes KE at the spring. Solve for v.

c) PE(top) = mg(-x) + PE(sp) You'll need the quadratic equation to solve this one.

(-x) = the amount the spring compresses.

81. The mass of water per second is not an initial velocity, so we take the initial velocity of the water at the top of the falls to be zero.

a) Use energy conservation and the height of the water fall to calculate the velocity of the water as it hits the turbine blades.

b) $P = \frac{W}{t}$. The work done is equal to the KE of the water as it hits the blades. Don't forget you only benefit from 60% of the work in this case.

82. This problem will take 4 steps.

i.) Use conservation of energy to solve for v^2 at the bottom in terms of v^2 at the top and gR.

ii) Solve for the Normal force at the bottom in terms of $\frac{mv_B^2}{R}$ and mg. Substitute v_B^2 with what you just found (v_B^2 in terms of v_T^2 and gR) previously. (It will be kind of messy).

iii.) Solve for the Normal force at the top in terms of $\frac{mv_T^2}{R}$ and mg.

iv) The difference in apparent weight is the difference between the normal force at the top and the normal force at the bottom. Subtract the two equations, F_{N_T} from F_{N_B}, and simplify.

84. TE(top) = TE(bottom) TE(top) = KE(top) + PE(top)
PE(bottom) = all KE because h=0. Substitute variables and solve for v(bottom)

91. Use the Work-Energy Theorem: W = ΔKE. Change km/h to m/s and find the work done to change from 35 km/h to 55 km/h. Use the time to calculate the power used. Assume power stays the same, calculate ΔKE for 55 km/h to 75 km/h and solve for time.