15. Helicopter blades withstand tremendous stresses. In addition to supporting the weight of a helicopter, they are spun at rapid rates and experience large centripetal accelerations, especially at the tip.
(a) Calculate the magnitude of the centripetal acceleration at the tip of a 4.00 m long helicopter blade that rotates at 300 rev/min. a=3.95e3 m/s^2

16. Olympic ice skaters are able to spin at about 5 rev/s.
(a) What is their angular velocity in radians per second?
(b) What is the centripetal acceleration of the skater's nose if it is 0.120 m from the axis of rotation?
w=31.4 rad/s, a=118 m/s^2

20. At takeoff, a commercial jet has a 60.0 m/s speed. Its tires have a diameter of 0.850 m.
(a) At how many rev/min are the tires rotating?
(b) What is the centripetal acceleration at the edge of the tire?
(c) With what force must a determined 1e-15 kg bacterium cling to the rim?
w=141 rad/s = 1.35e3 rpm, a=8.47e3 m/s^2, F=8.47e-12 N

19. A rotating space station is said to create "artificial gravity"---a loosely-defined term used for an acceleration that would be crudely similar to gravity. The outer wall of the rotating space station would become a floor for the astronauts, and centripetal acceleration supplied by the floor would allow astronauts to exercise and maintain muscle and bone strength more naturally than in non-rotating space environments. If the space station is 200 m in diameter, what angular velocity would produce an "artificial gravity" of 9.80 m/s^2 at the rim?
w=.313 rad/s=3 rpm

28. Part of riding a bicycle involves leaning at the correct angle when making a turn, as seen in Figure 6.36. To be stable, the force exerted by the ground must be on a line going through the center of gravity. The force on the bicycle wheel can be resolved into two perpendicular components: friction parallel to the road (this must supply the centripetal force), and the vertical normal force (which must equal the system's weight).
(a) Show tan θ =v^2/Rg

31. Modern roller coasters have vertical loops like the one shown in Figure 6.38. The radius of curvature is smaller at the top than on the sides so that the downward centripetal acceleration at the top will be greater than the acceleration due to gravity, keeping the passengers pressed firmly into their seats. What is the speed of the roller coaster at the top of the loop if the radius of curvature there is 15.0 m and the car just barely remins in contact with the rails?
It turns out that the increase in speed along a frictionless track equals the increase in speed for an equilivalent vertical fall. Find the height needed to start the car. Find the normal force at the bottom of the loop.
v^2=R g, h=R/2 (above top of loop), 6mg

Find the net force on the Moon if it is New, 1st Quarter, Full
G=6.674e-11
Mearth= 5.9724e+24, Msun= 1.9885e+30, Mmoon=7.35ee+22
Earth-Sun distance=1.496e11 Earth-Moon distance=3.84e8

ISS orbits 400 km up with a period of 92.65 minutes
the Moon orbits Earth-Moon distance=3.84e8 in 27.3 days;
check kepler's 3d: P^2/r^3 = constant; Rearth=6378137 m

```
* ? 92.65^2/(Rearth+400e3)^3
    .2756511569394287E-16
* ? (27.3*24*60)^2/(3.84e8)^3
    .2729333496093750E-16
```

What is the altitude of a geosynchronous satellite?

```
* ? ((24*60)^2/res)^(1/3)
    42213858.96663869
* ? (res-Rearth)/1609
    22272.04597056476    miles
```

Io: orbitR=421700 km, period=42.459 hours, find Mjupiter?

```
* ? (2*pi/(42.459*60*60))^2*421700e3^3/6.67e-11
    .1899766309121713E+28 (wiki: 1.8982e27 kg)
```

47. Astronomical observations of our Milky Way galaxy indicate that it has a mass of about 8.0e+11 solar masses. A star orbiting on the galaxy's periphery is about 6.0e+4 light years from its center. (a) What should the orbital periodof that star be? (b) If its period is 6.0e+7 year instead, whatis the mass of the galaxy? Msun=1.988e30

```
* ? 2*pi/sqrt(6.67e-11*8.0e+11*1.988e30)*(6.0e+4*c*year)^1.5/year
    261438215.8494172
* ? (2*pi/(6e7*year))^2*(6.0e+4*c*year)^3/6.67e-11
    .3019548491657213E+44
* ? res/Msun
    15185209263644.66
```

Mearth=5.972e+24 kg, Msun=1.989e+30 kg, Mmoon=7.342e+22 kg
Earth-Sun distance=1.496e11 m   Earth-Moon distance=3.84e8 m
Rearth=6378137 m

6. How much work is done by the boy pulling his sister 30.0 m in a wagon as shown in Figure 7.36? Assume no friction acts on the wagon.
1.30e3 J

5. Calculate the work done by an 85.0-kg man who pushes a crate 4.00 m up along a ramp that makes an angle of 20° with the horizontal. (See Figure 7.35.) He exerts a force of 500 N on the crate parallel to the ramp and moves at a constant speed. Be certain to include the work he does on the crate and on his body to get up the ramp.
just crate: 2000 J; self: mgh=85*9.8*4*sin(20)=1.14e3 J

20. A 100-g toy car is propelled by a compressed spring that starts it moving. The car follows the curved track in Figure 7.39. Show that the final speed of the toy car is 0.687 m/s if its initial speed is 2.00 m/s and it coasts up the frictionless slope, gaining 0.180 m in altitude.

A toy plane with a mass of 0.78 kg is tied to a string and made to travel at a speed of 24 m/s in a horizontal circle with a 15 m radius. The person holding the string pulls the plane in, increasing the tension in the string, increasing the speed of the plane and decreasing the radius of the plane's orbit. What is the net work done (in J) on the plane if the tension in the string is finally four time the initial tension iand the radius decreases to 11 m.
434 J

23. A pogo stick has a spring with a force constant of 2.50e4 N/m , which can be compressed 12.0 cm. To what maximum height can a child jump on the stick using only the energy in the spring, if the child and stick have a total mass of 40.0 kg? h=.459 m

25. (a) How high a hill can a car coast up (engine disengaged) if work done by friction is negligible and its initial speed is 110 km/h? (b) If, in actuality, a 750-kg car with an initial speed of 110 km/h is observed to coast up a hill to a height 22.0 m above its starting point, how much thermal energy was generated by friction? (c) What is the average force of friction if the hill has a slope 2.5° above the horizontal?
h=47.6 m, missing E=1.89e5 J, =F d where d=2.5/sin(2.5°)
F=375 N

A spring (spring constant k=250 N/m) is hanging from the ceiling. A mass (m=0.35 kg) is attached to the spring, pulled down 6 cm, nd then released. What is the velocity of the mass when it rises to 1 cm above the initial (relaxed, unattached) spring-end position (i.e., at y=+.01 m)? v=1.06 m/s
.5 k .06^2 +mg(-.06)=.5 m v^2 + .5 k .01^2 +mg(.01)
.5 k (.06^2-.01^2) + mg(-.07) = .5 m v^2
k/m (.06^2-.01^2) + 2g(-.07) = v^2

37. A 500 kg dragster accelerates from rest to a final speed of 110 m/s in 400 m (about a quarter of a mile) and encounters an average frictional force of 1200 N. What is its average power output in watts and horsepower if this takes 7.30 s?
P=4.80e5 W = 643 hp (746 W = 1 hp)

191t207.pdf W=-2400 J, KEf=9800 J, h=12.4 m

23. Train cars are coupled together by being bumped into one another. Suppose two loaded train cars are moving toward one another, the first having a mass of 150,000 kg and a velocity of 0.300 m/s, and the second having a mass of 110,000 kg and a velocity of -0.120 m/s . (The minus indicates direction of motion.) What is their final velocity?
.122 m/s

34. A battleship that is 6.00e7 kg and is originally at rest fires a 1100-kg artillery shell horizontally with a velocity of 575 m/s. (a) If the shell is fired straight aft
there will be negligible friction opposing the ship's recoil. Calculate its recoil velocity. (b) Calculate the increase in internal kinetic energy (that is, for the ship and the shell). This energy is less than the energy released by the gun powder--significant heat transfer occurs.
-1.05e-2 m/s, KEf=1.82e8 J

35. Two manned satellites approaching one another, at a relative speed of 0.250 m/s, intending to dock. The first has a mass of 4.00e3 kg , and the second a mass of 7.50e3 kg .
(a) Calculate the final velocity (after docking) by using the frame of reference in which the first satellite was originally at rest. (b) What is the loss of kinetic energy in this inelastic collision? (c) Repeat both parts by using the frame of reference in which the second satellite was originally at rest. Explain why the change in velocity is different in the two frames, whereas the change in kinetic energy is the same in both.   .163 m/s, ΔKE=-81.6 J;   -.087 m/s same

17. Water from a fire hose is directed horizontally against a wall at a rate of 50.0 kg/s and a speed of 42 m/s. Calculate the magnitude of the force exerted on the wall, assuming the water's horizontal momentum is reduced to zero. F=-2.10e3 N

old exam 105t212.pdf #14; KE conserved 25 J

30. A 70 kg ice hockey goalie, originally at rest, catches a 0.15 kg hockey puck slapped at him at a velocity of 35 m/s. Suppose the goalie and the ice puck have an elastic collision and the puck is reflected back in the direction from which it came. What would their final velocities be in this case? -34.85 m/s, .1497 m/s

29. Two manned satellites approach one another at a relative speed of 0.250 m/s, intending to dock. The first has a mass of 4e3 kg, and the second a mass of 7.5e3. If the two satellites collide elastically rather than dock, what is their final relative velocity? immediate: -.25 m/s
work in initial rest frame of 2: v2=0, v1=.25 m/s
v2'=.174 m/s, v1'=-.076 m/s

46 A 5.5 kg bowling ball moving at 9 m/s collides with a 0.85 kg bowling pin, which is scattered at an angle of 85° to the initial direction of the bowling ball and with a speed of 15 m/s. (a) Calculate the final velocity (magnitude and direction) of the bowling ball. (b) Is the collision elastic? (c) Is linear kinetic energy greater after the collision?
vy=-15*sin(85)*.85/5.5= -2.31 m/s
vx=(5.5*9-.85*15*cos(85))/5.5= 8.80...9.096 m/s @14.7° Yes

8. A car moving at 10 m/s crashes into a tree and stops in 0.26 s. Calculate the force the seat belt exerts on a passenger in the car to bring him to a halt. The mass of the passenger is 70 kg. F=2690 N

8-49. Ernest Rutherford (the first New Zealander to be awarded the Nobel Prize in Chemistry) demonstrated that nuclei were very small and dense by scattering helium-4 nuclei (4He) from gold-197 nuclei (197Au). The energy of the incoming helium nucleus was 8e-13 J and the masses of the helium and gold nuclei were 6.68e-17 kg 3.29e-25 kg respectively (note that their mass ratio is 4 to 197).
(a) If a helium nucleus scatters to an angle of 120° during an elastic collision with a gold nucleus, calculate the helium nucleus's final speed and the final velocity (magnitude and direction) of the gold nucleus. (b) What is the final kinetic energy of the helium nucleus?
v1f=15012135; angle=29.5°, v2f=536140

8-60. How much of a single-stage rocket that is 100,000 kg can be anything but fuel if the rocket is to have a final speed of 8 km/s, given that it expels gases at an exhaust velocity of 2.2e3 m/s? 2.63e3 kg

9-12. Suppose the weight of the drawbridge in Figure 9.34 is supported entirely by its hinges and the opposite shore, so that its cables are slack. (a) What fraction of the weight is supported by the opposite shore if the point of support is directly beneath the cable attachments? (b) What is the direction and magnitude of the force the hinges exert on the bridge under these circumstances? The mass of the bridge is 2500 kg. Fa=4083 Fb=20417 N

9-13. Suppose a 900-kg car is on the bridge in Figure 9.34 with its center of mass halfway between the hinges and the cable attachments. (The bridge is supported by the cables and hinges only.) (a) Find the force in the cables. (b) Find the direction and magnitude of the force exerted by the hinges on the bridge T=1.32e4 N, Fx=1.01e4 N Fy=2.48e4 N

```
* let m12=4/197
* let v1=sqrt(2*8e-13/6.68e-27)
* let a=1+m12
* let b=-2*m12*v1*cos(2*pi/3)
* let c=-(1-m12)*v1^2
* let v1f= (-b+sqrt( b^2-4*a*c))/(2*a)
* let v2yf=m12*v1f*sin(2*pi/3)
* let v2xf=m12*(v1-v1f*cos(2*pi/3))
* ? atan(v2yf/v2xf)*180/pi
   29.49622174556288
* ? .5*6.68e-27*v1f^2/8e-13
   .9408955678530254
```

17. To get up on the roof, a person (mass 70 kg) places a 6 m aluminum ladder (mass 10 kg) against the house on a concrete pad with the base of the ladder 2 m from the house. The ladder rests against a plastic rain gutter, which we can assume to be frictionless. The center of mass of the ladder is 2 m from the bottom. The person is standing 3 m from the bottom. What are the magnitudes of the forces on the ladder at the top and bottom?
Q: is the force at the top horizontal or perpendicular to ladder?
Ftop=133 N or 125 N (friction=118 N, N=742 N)

34. A father lifts his child as shown in Figure 9.43. What force should the upper leg muscle exert to lift the child at a constant speed? 2254 N

21. a) What is the mechanical advantage of a wheelbarrow, such as the one in Figure 9.24, if the center of gravity of the wheelbarrow and its load has a perpendicular lever arm of 5.5 cm, while the hands have a perpendicular lever arm of 1.02 m? (b) What upward force should you exert to support the wheelbarrow and its load if their combined mass is 55 kg? (c) What force does the wheel exert on the ground?
MA=102/5.5=18.55, Fhand=29.1 N, N=W-29.1=510 N

37. (a) What force should the woman in Figure 9.45 exert on the floor with each hand to do a push-up? Assume that she moves up at a constant speed. (b) The triceps muscle at the back of her upper arm has an effective lever arm of 1.75 cm, and she exerts force on the floor at a horizontal distance of 20 cm from the elbow joint. Calculate the magnitude of the force in each triceps muscle, and compare it to her weight.
(c) How much work does she do if her center of mass rises 0.24 m?
(d) What is her useful power output if she does 25 pushups in one minute? .5*W*.9/1.5=147 N, 147*20/1.75=1680 N, 118 J, 49 W

3. You have a grindstone (a disk) that is 90 kg, has a 0.34 m radius, and is turning at 90 rpm, and you press a steel axe against it with a radial force of 20 N. (a) Assuming the kinetic coefficient of friction between steel and stone is 0.20, calculate the angular acceleration of the grindstone. (b) How many turns will the stone make before coming to rest?
α=-.26 rad/s^2, θ=27 rev

8. During a very quick stop, a car decelerates at 7 m/s^2 .
(a) What is the angular acceleration of its 0.28 m radius tires, assuming they do not slip on the pavement?
(b) How many revolutions do the tires make before coming to rest, given their initial angular velocity is 95 rad/s ?
(c) How long does the car take to stop completely?
(d) What distance does the car travel in this time?
(e) What was the car's initial velocity?
α= -25 rad/s^2, θ=28.7 rev, t=3.8 s, x=50.7 m, v=26.6 m/s

16. Zorch, an archenemy of Superman, decides to slow Earth's rotation to once per 28.0 h by exerting an opposing force at and parallel to the equator. Superman is not immediately concerned, because he knows Zorch can only exert a force of 4.E7 N (a little greater than a Saturn V rocket's thrust). How long must Zorch push with this force to accomplish his goal?
Mearth=5.9724E+24 kg, Rearth= 6.3781E+06 m, t=3.95e18 s

13. A soccer player extends her lower leg in a kicking motion by exerting a force with the muscle above the knee in the front of her leg. She produces an angular acceleration of 30 rad/s^2 and her lower leg has a moment of inertia of 0.750 kg m^2 . What is the force exerted by the muscle if its effective perpendicular lever arm is 1.90 cm?
F=1.18e3 N

old exam 2 #18
a=(Mg-f)/(I/Rr+M)=.77 m/s^2

39. A playground merry-go-round has a mass of 120 kg and a radius of 1.8 m and it is rotating with an angular velocity of 0.500 rev/s. What is its angular velocity after a 22 kg child gets onto it by grabbing its outer edge? The child is initially at rest. w=.366 rev/s = 2.30 rad/s

43. Repeat Example 10.15 in which the disk strikes and adheres to the stick 0.1 m from the nail.

Suppose the disk in Figure 10.26 has a mass of 50 g and an initial velocity of 30 m/s when it strikes the stick that is 1.2 m long and 2 kg.
(a) What is the angular velocity of the two after the collision?
(b) What is the kinetic energy before and after the collision?
(c) What is the total linear momentum before and after the collision?
Li=mvx=Lf=(I+mx^2) w; Irod=1/3 ML^2; KE=1/2 I w^2
w= (.05 30 .1)/(1/3 2 1.2^2 + .05 .1^2) = .156 rad/s
KEi=22.5 J, KEf=1/2 (I+mx^2) w^2 = 1.08e-2 J
pi=1.5 kg m/s; pf=(m x + M L/2)w=.188 kg m/s
(reduced p means a negative--backward-- impulse from nail)

105iQt2.pdf p 24 & 25