REMOVE THIS COVER SHEET ONLY WHEN TOLD TO DO SO. MAKE SURE TO PUT YOUR NAME ON THE FIRST PAGE OF THE EXAM BEFORE YOU TURN IT IN.

Possibly useful information:

She packed my bags last night, pre-flight
Zero hour, nine A.M.
And I'm gonna be high as a kite by then
I miss the earth so much I miss my wife
It's lonely out in space
On such a timeless flight

Mars ain't the kind of place to raise your kids
In fact, it's cold as hell
And there's no one there to raise them if you did
And all this science I don't understand
It's just my job five days a week
A rocket man...

And I think it's gonna be a long long time
Till touchdown brings me round again to find
I'm not the man they think I am at home
Oh no, no, no — I'm a rocket man
A rocket man, burning out his fuse
Up here alone

B. Taupin

\[ F_{\text{grav}} = G \frac{m_1 m_2}{r^2} \]

\[ v = r \omega \]

\[ a_c = \frac{v^2}{r} = r \omega^2 \]

\[ \tau_{\text{net}} = I \alpha \quad \tau = Fr_\perp \]

\[ \theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2 \]

\[ I_{\text{point}} = mr^2 \]

\[ I_{\text{sphere}} = \frac{2}{5} mr^2 \]

\[ I_{\text{disk}} = \frac{1}{2} mr^2 \]

\[ L = I \omega \]

\[ \text{Rot.KE} = \frac{1}{2} I \omega^2 \]

\[ |g| = 9.8 \, \text{m/s}^2 \]

\[ G = 6.673 \times 10^{-11} \, \text{N m}^2/\text{kg}^2 \]

Possibly useful advice:

As always, show all your work and circle your final answer (both numerical and multiple choice). All numeric values are good to 3 significant figures. Ask questions if you have them. Show your work clearly for partial credit. Don’t take any wooden nickels. Ignore air resistance. Enjoy!
You should have three (3) pages in this exam, not including the cover sheet.
As always, show all your work and circle your final answer (both numerical and multiple choice). All numeric values are good to 3 significant figures. Ignore air resistance. You should have three (3) pages in this exam, not including the cover sheet.

Multiple choice: Each question is worth 5 points (30 points total).

1. Jupiter orbits the Sun at a slower speed than the Earth. Why?
   - A. because of Jupiter’s mass
   - B. because of Jupiter’s radius
   - C. because of Jupiter’s distance from the Sun
   - D. both A. & B.
   - E. both A. & C. +2

2. Your electric bill charges you for using a certain number of “kilowatt-hours.” This is a unit of:
   - A. Force
   - B. Energy +5
   - C. Power
   - D. Volts
   - E. Amps

3. A hoop (with all its mass on the outside), and disk (with its mass distributed uniformly), and a frictionless block all race down a ramp. The hoop and disk roll, while the block slides without friction. In what order do these complete the race?
   - A. Block, disk, hoop. +5
   - B. Block, hoop, disk.
   - C. Disk, hoop, block.
   - D. Hoop, disk, block.
   - E. Two of these objects tie. +5
   - F. More information is necessary to know the result.

4. Considering kinetic energy and work, by what factor would your necessary stopping distance change if you increased your car’s velocity by a factor of 3.00?
   - A. No change in stopping distance
   - B. 1.73 times the stopping distance
   - C. 3.00 times the stopping distance +5
   - D. 4.00 times the stopping distance
   - E. 3.00 times the stopping distance

5. Dr. Carroll pushes a crate of apples up a frictionless inclined plane at a slope of 30° so that it is now 2.00 m above the ground. Dr. Palen pushes the same crate of apples up a frictionless inclined plane at a slope of 45° so that it is 2.00 m above the ground, just as Dr. Carroll’s crate was. Which of the following quantities is the same for each of these two crates?
   - A. The work done to each crate. +5
   - B. The change in potential energy of each crate. +5
   - C. The force exerted on each crate.
   - D. Both A & B.
   - E. Both B & C.

6. Two balls collide with one another head on, so that they both have motion before and after the collision. The balls are confined to the top of a flat table (like a pool table). If the collision is an elastic collision, how would you go about solving a problem in which you are asked about both of the balls’ final velocities?
   - A. Use conservation of momentum. +5
   - B. Use conservation of kinetic energy. +5
   - C. Use conservation of potential energy.
   - D. Both A & B.
   - E. Both A & C.
Situation #1: Indiana Johnston (40 points total):
Just like Indiana Jones, your physics professor often takes
part in dangerous adventures when he is not in class or in
his office. Imagine him (M=70.0 kg) swinging on a vine
(r=8.00 m) from a height (h=4.00 meters) to saved his dog,
Tycho (m=16.0 kg).

A. [15 points] What is the professor's velocity at the
bottom of the swing, just before he collides with
Tycho?

\[ \text{Use conservation of energy:} \]

\[ E_i = E_f \]

\[ mgh = \frac{1}{2} mv^2 \rightarrow v = \sqrt{2gh} = \sqrt{2(9.8 \text{ m/s}^2)(4.00 \text{ m})} \]

\[ = 8.85 \text{ m/s} \]

B. [10 points] What is the velocity of the professor and Tycho just after the collision, assuming that they
stick together?

\[ M = 70 \text{ kg} \]
\[ m = 16 \text{ kg} \]

\[ P_i = P_f \text{ STUCK TOGETHER} \]

\[ Mv_i = (M+m)v_f \]

\[ v_f = \frac{Mv_i}{M+m} = \frac{(70 \text{ kg})(8.85 \text{ m/s})}{70 \text{ kg} + 16 \text{ kg}} \]

\[ = 7.21 \text{ m/s} \]

C. [15 points] What is the tension in the vine at the bottom of the swing, just AFTER the professor
collides with Tycho?

\[ F_{net} = ma \]
\[ T - mg = m_a \frac{v^2}{r} \]
\[ (m_T = M+m) \]

\[ T = (M+m) \left( \frac{v^2}{r} + g \right) = (70+16 \text{ kg}) \left( \frac{(7.21 \text{ m/s})^2}{8 \text{ m}} + 9.8 \text{ m/s}^2 \right) \]

\[ = 1400 \text{ N} \]
Situation #2: Fun with rotation (30 points total)

A. [15 points] A 1.80 m radius playground merry-go-round has a mass of 120 kg and is rotating with an angular velocity of 0.500 revolutions per second. What is its angular velocity after a 22.0 kg child gets onto it by grabbing its outer edge? (The child was initially at rest.)

\[
I_f \omega_f = I_i \omega_i \\
\Rightarrow \frac{I_f}{I_i} \omega_f = \omega_i
\]

\[
= \frac{1}{2} M_{\text{disk}} r^2 - \frac{1}{2} M_{\text{disk}} r^2 + m_r r^2
\]

\[
\Rightarrow \omega_f = \frac{1}{2} \frac{(120 \text{kg})(1.8 \text{m})^2 \cdot 5 \text{ rev}}{5}
\]

\[
= 36 \frac{\text{rad}}{\text{s}}
\]

B. [15 points] Adam has a special projectile launcher that gets all its energy from a special flywheel (like the one on the bus in your homework in chapter 9). This launcher’s flywheel is a rotating disk with a 0.500 m radius and has a mass of 8.00 kg, and it is rotating at 10.0 rad/s. If this launcher gives all of its rotational energy to a 2.00 kg zucchini in order to launch it from the roof of the science building (h=20.0 m above the ground), what is the total speed of the zucchini just before it hits the ground? (Note: It might be helpful to realize that only the total speed is being asked for – not the velocity with direction.)

\[
E_0 = E_f
\]

\[
\frac{1}{2} I \omega^2 + m g h = \frac{1}{2} m v^2
\]

\[
(I_{\text{disk}} = \frac{1}{2} M_{\text{disk}} r^2)
\]

\[
V^2 = \frac{8}{8 \text{ rad}} \left( \frac{1}{2} M_{\text{disk}} r^2 \omega^2 + 2 g h \right)
\]

\[
V = \sqrt{\frac{8}{2} \frac{(5 \text{m})^2 (10 \text{ rad})^2}{2 \text{ kg}} + 2 (9.8 \text{ m/s}^2)(20 \text{ m})} = \frac{21.0 \text{ m}}{\text{s}}
\]