This exam consists of 13 problems. Please check that you have all of them. One (both sides) 8 1/2” x 11” crib sheet is allowed. It must be of your own creation.

Useful formulas and constants:
\[
\sin \theta = \frac{y}{r} \quad \cos \theta = \frac{x}{r} \quad \tan \theta = \frac{y}{x}
\]

\[ g = 9.8 m/s^2 \]

Constant acceleration
\[
x = x_0 + v_0t + \frac{1}{2}at^2 \quad v = v_0 + at \quad v^2 = v_0^2 + 2a(x - x_0)
\]

Also used:
\[
x - x_0 = \frac{1}{2}(v_{ox} + v_x) t
\]

\[
T = \frac{4\pi^2r^3}{GM_E}
\]

\[
\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)
\]

Please sign the opscan sheet and print your name on it.
Use a #2 pencil to fill in your full name, your student identification number (old one), and finally the answers for problems 1–13.
Please be prepared to show your Purdue ID when you hand in your opscan sheet.
1. A box is sliding down an incline at constant acceleration. The angle of the incline is 25 degrees and the coefficient of kinetic friction is 0.2. The acceleration of the box is,

\[ a_x = \frac{\Sigma F_x}{m} = \frac{-f_k + \omega x}{m} = \frac{-u_k N + mg \sin \theta}{m} = \frac{-u_k (mg \cos \theta) + mg \sin \theta}{m} = \max \]

\[ a_x = -u_k g \cos \theta + g \sin \theta = 2.37 \text{ m/s}^2 \]

A) 0.9 m/s²
B) 1.0 m/s²
C) 1.3 m/s²
D) 2.4 m/s²
E) 2.2 m/s²

2. A locust jumps with a velocity of 3 m/s at an angle of 55 degrees above the horizontal. The locust lands 0.8 m from where it jumped. What is the time it takes the locust to reach its maximum height?

\[ v_0 = 3 \text{ m/s} \]
\[ \theta = 55^\circ \]
\[ v_y = 0 \]
\[ x = \frac{1}{2} R = 0.4 \text{ m} \]

A) 0.051 s
B) 0.12 s
C) 0.25 s
D) 0.47 s
E) 0.50 s

3. Two masses are suspended by cord that passes over a pulley with negligible mass. The cord also has negligible mass. One of the masses, \( m_1 \), has a mass of 5.0 kg and the other mass, \( m_2 \), has a mass of 3.0 kg. The acceleration of \( m_1 \) is:

\[ a_1 = 2.45 \text{ m/s}^2 \]

A) 3.25 m/s² upward
B) 3.25 m/s² downward
C) 2.45 m/s² upward
D) 2.45 m/s² downward
E) 1.05 m/s² upward
4. In the figure below, a airport luggage carrying train with a tractor T is pulling three.
luggage carts, M₁, M₂, and M₃, with an acceleration of 1.4 m/s². If T = 300 kg, M₁ = 200
kg, M₂=100 kg, and M₃ =100 kg, then the force in the connection between the tractor T
and cart M₁ is,

\[ \sum F_x = m_a \]

\[ F = m_a \]

\[ F = (m_1 + m_2 + m_3) a \]

\[ F = (200 \text{ kg} + 100 \text{ kg} + 100 \text{ kg})(1.4 \text{ m/s}^2) \]

\[ F = 560 \text{ N} \]

A) 890N  
B) 560N  
C) 280N  
D) 140N  
E) 0N

5. A car starting from rest travels a distance of 20.0 m with a constant acceleration of 2.0
m/s². The car then slows to a stop in 10.0 seconds with a constant negative acceleration.
The distance traveled by the car during the whole time period (from start to stop) is:

**First part**

A) 36.8 m  
B) 46.2 m  
C) 50.1 m  
D) 58.3 m  
E) 64.7 m

\[ x_0 = 0 \]
\[ x = 20 \text{ m} \]
\[ v_x = 0 \]
\[ a_x = 2.0 \text{ m/s}^2 \]
\[ t = ? \]
\[ v_x = \sqrt{2a_x} = 8.94 \text{ m/s} \]

**Second part**

\[ x_0 = 20 \text{ m} \]
\[ x = \text{ want} \]
\[ v_{0x} = \text{ need} = v_x \text{ from First part} = 8.94 \text{ m/s} \]
\[ v_x = 0 \]
\[ a_x = \text{ negative} \]
\[ t = 10 \text{ s} \]
\[ x-x_0 = \frac{1}{2} (v_{0x} + v_x^2) t \]
\[ x = x_0 + \frac{1}{2} v_{0x} t \]
\[ x = 20 \text{ m} + \frac{1}{2} (8.94 \text{ m/s}) (10 \text{ s}) \]
\[ x = 64.7 \text{ m} \]
6. A spy satellite is in a circular orbit around Earth. It makes one revolution in 6 hours. How high above the Earth's surface is the satellite?

(Useful constants: \( G = 6.673 \times 10^{-11} \text{Nm}^2/\text{kg}^2 \); \( R_{\text{Earth}} = 6.371 \times 10^6 \text{m} \); \( M_{\text{Earth}} = 5.975 \times 10^{24} \text{kg} \))

A) 16,771 km
B) 10,400 km
C) 331 km
D) 6,702 km
E) 8,385 km

\[
\tau = \frac{4\pi^2 r^3}{GM_{\text{Earth}}}
\]

\[
r = \sqrt[3]{\frac{T^2 GM_{\text{Earth}}}{4\pi^2}}
\]

\[
h = r - R_{\text{Earth}}
\]

\[
h = \frac{10391437 \text{ m}}{1000 \text{ m}} = 10391 \text{ km}
\]

7. A 0.5 kg stone is moving in a circular path attached to a string that is 75 cm long. The stone is moving around the path at a constant frequency of 1.5 rev/sec. At the moment the stone is overhead, the stone is released. The velocity of the stone when it leaves the circular path is,

\[
m = 0.5 \text{ kg}
\]

\[
r = 75 \text{ cm} = 0.75 \text{ m}
\]

\[
f = 1.5 \text{ rev/s} = 1.5 \text{ Hz}
\]

\[
\nu = ?
\]

A) 5.55 m/s
B) 7.07 m/s
C) 7.75 m/s
D) 8.35 m/s
E) 9.00 m/s

\[
V_T = r \omega \quad \omega = 2\pi f
\]

\[
V_T = r \cdot 2\pi f = \frac{7.069 \text{ m/s}}{}
\]

8. An 80 kg person is riding in an elevator that is accelerating at 2.4 m/s² downward. The weight of the 80 kg person measured on a scale in the elevator is:

A) 592 N
B) 639 N
C) 784 N
D) 855 N
E) 976 N

\[
\sum F_y = ma_y
\]

\[
m - mg = ma_y
\]

\[
N = mg + ma_y
\]

\[
N = \{80\text{kg}(9.8\text{m/s}^2)\} + \{80\text{kg}(2.4\text{m/s}^2)\}
\]

\[
N = 592 \text{ N}
\]
9. A 2000 kg car is traveling on a banked curved icy road. The velocity of the car is 25 m/s and the road has a radius of curvature of 500 m. If the car is to travel on the icy road without sliding, then the angle of the banked road is,

\[ \theta = \tan^{-1} \left( \frac{v^2}{rg} \right) \]

\[ v = 25 \text{ m/s} \]
\[ r = 500 \text{ m} \]
\[ g = 9.8 \text{ m/s}^2 \]

A) 25.7 degrees  
B) 21.0 degrees  
C) 12.7 degrees  
D) 10.5 degrees  
(E) 7.27 degrees

10. If the length of the Achilles tendon increases 0.50 cm when the force exerted on it by the muscle increases from 3200 N to 4800 N, what is the "spring constant" of the tendon?

\[ F = kx \]
\[ k = \frac{F}{x} = \frac{\text{additional force}}{\text{additional lengthening}} \]
\[ k = \frac{4800 \text{ N} - 3200 \text{ N}}{0.50 \text{ cm}} = 3200 \text{ N/cm} \]

A) 3200 N/cm  
B) 6400 N/cm  
C) 9600 N/cm  
D) 16,000 N/cm  
(E) 8,000 N/cm

11. During normal operation, a computer's hard disk spins at 7,200 rpm. If it takes the hard disk 4 s to reach this angular velocity starting from rest, what is the average angular acceleration of the hard disk in rad/s²?

\[ \omega = 0 \]
\[ \omega_0 = 0 \]
\[ \omega = 753.98 \text{ rad/s} \]
\[ \alpha = \omega / t = \frac{753.98 \text{ rad/s}}{4 \text{ s}} = 188.5 \text{ rad/s}^2 \]

A) 1800 rad/s²  
B) 900 rad/s²  
C) 380 rad/s²  
(D) 190 rad/s²  
E) 6.82 rad/s²
12. An airplane is climbing at an angle of 5 degrees above the horizontal at a constant velocity. The weight of the airplane is 40,000 N. The wings (which are also making an angle of 5 degrees above the horizontal) produce a lift force that is perpendicular to the wings and a drag force that is parallel to the wings. The drag force is 1,600 N. The forward thrust force the engine produces is:

A) 3,200 N  
B) 5,100 N  
C) 8,300 N  
D) 10,500 N  
E) 12,000 N

13. Grant Hill jumps 1.3 m straight up into the air to slam-dunk a basketball into the net. With what speed did he leave the floor?

A) 3.6 m/s  
B) 5.0 m/s  
C) 25.5 m/s  
D) 12.7 m/s  
E) 9.8 m/s

\[ V_y^2 = V_{oy}^2 + 2a_y (y - y_0) \]
\[ V_{oy}^2 = -2a_y y \]
\[ V_{oy} = \sqrt{-2a_y y} = \sqrt{-2(-9.8 \text{ m/s}^2)(1.3 \text{ m})} \]
\[ V_{oy} = 5.05 \text{ m/s} \]