

Exam-2 Solutions (S16)

1.) Multiple Choice

(18 pts.)

For each statement below, circle the correct answer (TRUE or FALSE, no reasoning required).

- (a) The acceleration of a satellite in orbit depends on the mass of the satellite.
TRUE FALSE
- (b) The gravitational force between any two masses can be either attractive or repulsive.
TRUE FALSE
- (c) The normal force is a conservative force.
TRUE FALSE
- (d) The kinetic energy of an object cannot be negative.
TRUE FALSE
- (e) If negative net work is done on an object, its speed decreases.
TRUE FALSE
- (f) When a tennis ball bounces elastically off a wall, its momentum does not change.
TRUE FALSE

No.	Points
1	YZ
2	JW
3	TW
4	CH
5	RR
Sum	

3.) Mechanical Energy Conservation

(20 pts.)

A monkey is sitting on a tree branch 2 m above the ground. He jumps off the branch at an initial speed of 6 m/s . Use energy conservation to calculate

- (a) the maximal speed of the monkey when jumping to the ground.
- (b) the maximal height he can reach in the tree when jumping straight up.

$$(a) \quad E_0 = E_1$$

$$\frac{1}{2} m v_0^2 + m g h_0 = \frac{1}{2} m v_1^2$$

$$\Rightarrow \boxed{v_1 = \sqrt{v_0^2 + 2gh} = 8.67 \text{ m/s}}$$

$$(b) \quad E_0 = E_2$$

$$\frac{1}{2} m v_0^2 + m g h_0 = m g h_{\max}$$

$$\boxed{h_{\max} = h_0 + \frac{v_0^2}{2g} = 3.84 \text{ m}}$$

2.) Centripetal Force in Circular Motion

(20 pts.)

A coin is placed on a small wooden horizontal turn table at a distance of 10 cm from the center. The turn table then starts rotating. The static friction coefficient between turn table and coin is 0.7.

- (a) What is the maximal centripetal acceleration that the friction force can support?
(b) Calculate the period of the coin's circular motion when rotating at maximal speed.

(a)

$$F_c = f_s$$

$$m a_c^{\max} = \mu_s F_N = \mu_s mg$$

$$\Rightarrow \boxed{a_c^{\max} = \mu_s g = 6.86 \text{ m/s}^2}$$

(b)

$$v = \frac{2\pi R}{T} \Rightarrow T = \frac{2\pi R}{v}$$

$$\frac{mv^2}{R} = \mu_s mg \Rightarrow v^2 = \mu_s Rg$$

$$\Rightarrow \boxed{T = \frac{2\pi R}{\sqrt{\mu_s Rg}} = 2\pi \sqrt{\frac{R}{\mu_s g}} = 0.76 \text{ s}}$$

4.) Elastic Collision

(18 pts.)

Block 1 (mass $m_1=40\text{ kg}$) and block 2 (mass $m_2=8\text{ kg}$) are forced toward each other compressing a spring between them. After being released from rest the blocks recede from each other on a horizontal frictionless surface and leave the massless relaxed spring behind. Block 1 is found to have a final speed of 0.9 m/s .

(a) What is the final speed of block 2?

(b) What is the energy stored in the spring before the blocks are released?

$$(a) \quad p_o = p_f$$

$$0 = m_1 v_{1f} + m_2 v_{2f}$$

$$v_{2f} = -\frac{m_1}{m_2} v_{1f} = -4.5 \text{ m/s}$$

$$\text{or } v_{2f} = 4.5 \frac{\text{m}}{\text{s}}$$

$$(a) \quad E_{\text{spring}} = K_{1f} + K_{2f}$$

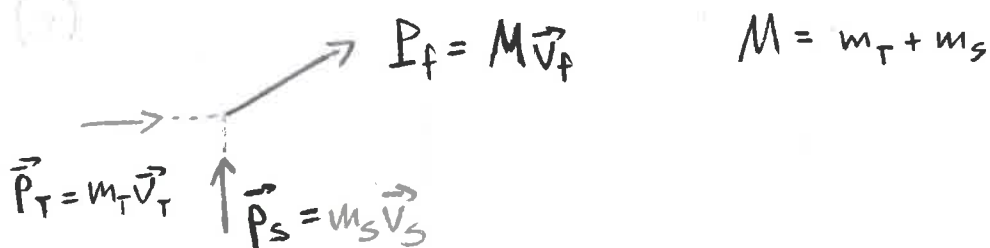
$$= \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2 = 97.2 \text{ J}$$

5.) Non-Conservative Work and Momentum Conservation

(24 pts.)

A sedan (mass $m_S=1200\text{ kg}$), traveling due north through an intersection, is hit by a truck (mass $m_T=2000\text{ kg}$), traveling due east. The two cars are stuck together and slide at an angle of $\Theta=25^\circ$ north of east away from the collision point, leaving behind an 11 m long tire track before coming to a stop. The kinetic friction coefficient between the road and the tires is 0.95 .

- Calculate the work done by the friction force to bring the the stuck-together cars to a stop.
- Calculate the total momentum (x- and y-component) of the stuck-together cars right after the collision.
- Calculate the speed of each car before the collision.



$$(a) \quad \boxed{W_{nc} = -f_k d = -\mu_k F_N d = -\mu_k M g d = -327712 \text{ J}}$$

$$(b) \quad \Delta K = W_{nc} \Rightarrow K_i = -W_{nc} = \frac{1}{2} M v_f^2$$

$$\Rightarrow v_f = \sqrt{-2 W_{nc} / M} = 14.3 \text{ m/s}$$

$$\boxed{\begin{aligned} p_{fx} &= M v_{fx} = M v_f \cos \theta = 41506 \frac{\text{kg m}}{\text{s}} \\ p_{fy} &= M v_{fy} = M v_f \sin \theta = 19355 \frac{\text{kg m}}{\text{s}} \end{aligned}}$$

$$(c) \quad \boxed{m_S v_S = p_{fy} \Rightarrow v_S = \frac{p_{fy}}{m_S} = 16.1 \frac{\text{m}}{\text{s}} = 36 \text{ mph}}$$

$$\boxed{m_T v_T = p_{fx} \Rightarrow v_T = \frac{p_{fx}}{m_T} = 20.75 \frac{\text{m}}{\text{s}} = 47 \text{ mph}}$$