

Put the answers to these 15 questions on your SCANTRON sheet. Your answer should be CLOSEST TO THE GIVEN ANSWERS. The given answers assume a value of $g = 10 \text{ m/s}^2$.

As a student at NJIT I (sign) _____, will conduct myself in a professional manner and will comply with the provisions of the NJIT Academic Honor Code. I also understand that I must subscribe to the following pledge on major work submitted for credit as described in the NJIT Academic Honor code: On my honor, I pledge that I have not violated the provisions of the NJIT Academic Honor Code.

1. A 0.2-kg hockey puck sent sliding over the ice is stopped in 15 m by the frictional force on it from the ice. If the initial speed of the puck is 9 m/s what is the coefficient of kinetic friction between the puck and the ice?

- (A) 0.12
- (B) 0.42
- (C) 0.18
- (D) 0.05
- (E) 0.27

$v_i = 9 \text{ m/s}$ $v_f = 0$

$$v_f^2 - v_i^2 = 2a(x - x_0)$$

$$0 - 9^2 = 2a(15)$$

$$a_x = \frac{0 - 9^2}{2 \times 15} = -2.7 \text{ m/s}^2$$

Free-body diagram equations:

$$F_{\text{net},y} = +|F_N| - mg = 0 \implies |F_N| = mg$$

$$F_{\text{net},x} = -|F_f| = ma_x$$

$$-\mu_k |F_N| = ma_x$$

$$-\mu_k mg = ma_x$$

2. A small 600-kg car travels across the crest of a circular hump of radius 22.5 m. What is the maximum speed at which the car can go over the hump without losing contact with the road?

- (A) 15 m/s
- (B) 25 m/s
- (C) 20 m/s
- (D) 10 m/s
- (E) 30 m/s

$R = 22.5 \text{ m}$

$a = \text{down}$

$$F_{\text{net},y} = +|F_N| - mg = m\left(-\frac{v^2}{r}\right)$$

$$|F_N| = m\left(g - \frac{v^2}{r}\right)$$

$|F_N| = 0$ for v_{max}

$$g - \frac{v_{\text{max}}^2}{r} = 0 \implies v_{\text{max}} = \sqrt{rg} = \sqrt{22.5 \times 10} = 15 \text{ m/s}$$

$\mu_k = -\frac{a_x}{g} = -\frac{-2.7}{10} = 0.27$

3. A 2-kg mass swings in a vertical circle at the end of a 0.8 m string at a constant speed of $v = 4 \text{ m/s}$. What is the tension in the string at the bottom of the circle?

- (A) 20 N
- (B) 28 N
- (C) 40 N
- (D) 60 N
- (E) 50 N

$a = \text{up}$

$$F_{\text{net},y} = |T| - mg = m\left(\frac{v^2}{r}\right)$$

$$|T| = mg + m\frac{v^2}{r} = m\left(g + \frac{v^2}{r}\right)$$

$$= 2 \times \left(10 + \frac{4^2}{0.8}\right) = 60$$

4. A block is pulled up a frictionless incline by a tension $T = 30 \text{ N}$ at a constant speed. What is the mass of the block?

- (A) 17 kg
- (B) 6 kg
- (C) 12 kg

$\theta = 30^\circ$

$$F_{\text{net},x} = |T| - mg \sin \theta = ma_x = 0$$

$$\implies |T| = mg \sin \theta$$

$$m = \frac{|T|}{g \sin \theta} = \frac{30}{10 \times \sin 30^\circ} = 6 \text{ kg}$$

- (D) 8 kg
- (E) 3 kg

5. What is the smallest value of the force F such that the 3.0-kg block will not slide down the wall?

- (A) 80 N
- (B) 120 N
- (C) 45 N
- (D) 60 N
- (E) 10 N

$F_{net,x} = |\vec{F}_n| - |\vec{F}| = 0 \Rightarrow |\vec{F}_n| = |\vec{F}|$
 $F_{net,y} = +|f_s^{max}| - mg = 0 \Rightarrow |f_s^{max}| = mg$
 $\mu_s |\vec{F}_n| = \mu_s |\vec{F}| = mg \Rightarrow \mu_s \frac{|\vec{F}|}{|\vec{F}|} = \frac{mg}{|\vec{F}|} \Rightarrow \mu_s = \frac{mg}{|\vec{F}|} \Rightarrow |\vec{F}| = \frac{mg}{\mu_s} = \frac{3 \times 10}{0.5} = 60 \text{ N}$

6. The 5-kg box sits on the back of the truck traveling at 20 m/s. Determine the minimum stopping distance of the truck so that the box does not slide when truck decelerates.

- (A) 40 m
- (B) 50 m
- (C) 15 m
- (D) 25 m
- (E) 88 m

Static friction
 For min. stopping distance,
 it's max. static friction



$\mu_s |\vec{F}_n| = m a_x$
 $\mu_s mg = m a_x \Rightarrow a_x = \mu_s g = 0.5 \times 10 = 5$
 $v_f^2 - v_i^2 = 2a(x - x_0)$
 $0 - 20^2 = 2 \times 5 \times (x - x_0) \Rightarrow x - x_0 = -40 \text{ m}$

7. A 8-kg block is pulled along a rough horizontal surface ($\mu_k = 0.2$) by a rope that exerts a 30 N tension force directed 30° above the horizontal. What is the magnitude of the friction force on the block?

- (A) 73 N
- (B) 58 N
- (C) 45 N
- (D) 20 N
- (E) 13 N

$F_{net,y} = |\vec{F}_n| - mg + |\vec{T}| \sin \theta = 0$
 $|\vec{f}_a| = \mu_k (|\vec{F}_n|)$

$= \mu_k (mg - |\vec{T}| \sin \theta)$
 $= 0.2 \times (8 \times 10 - 30 \cdot \sin 30^\circ) = 13 \text{ N}$

8. The coefficient of static friction between the road and the tires is 0.521. What speed will put the car on verge of sliding as it makes a turn of radius 120 m? The road is flat.

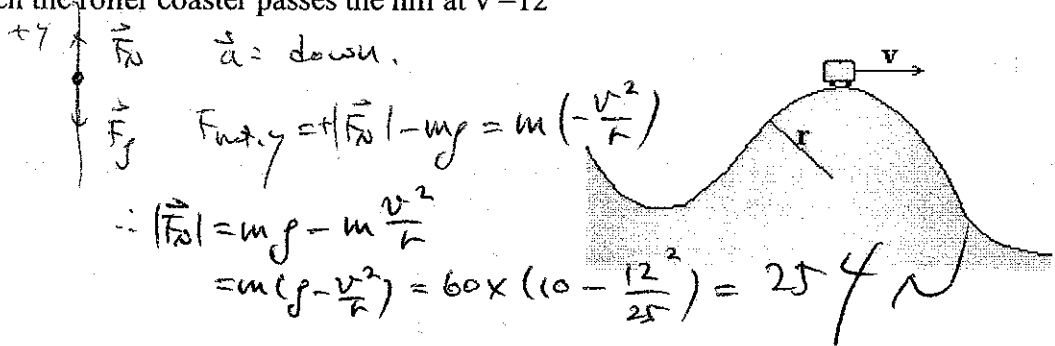
- (A) 10 m/s
- (B) 25 m/s
- (C) 33 m/s
- (D) 43 m/s
- (E) 50 m/s

$F_{net,y} = |\vec{F}_n| - mg = 0 \Rightarrow |\vec{F}_n| = mg$

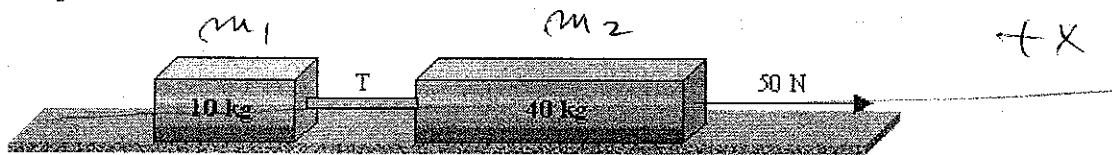
$-\mu_s |\vec{F}_n| = m(-\frac{v^2}{r})$
 $-\mu_s mg = -m \frac{v^2}{r} \Rightarrow v^2 = \mu_s r g$
 $v_{max} = \sqrt{\mu_s r g} = \sqrt{0.521 \times 120 \times 10} = 25.0 \text{ m/s}$

9. A roller coaster track has a hill with a circular curve of radius $r=25$ m. What is the normal force on the 60-m/s passenger when the roller coaster passes the hill at $v=12$ m/s?

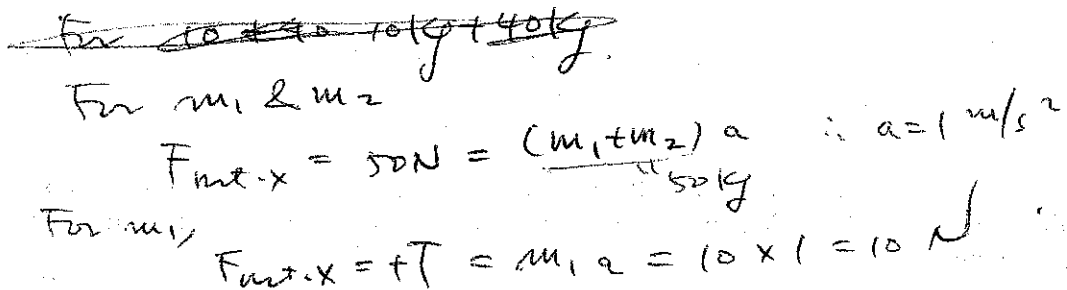
- (A) 254 N
 (B) 386 N
 (C) 588 N
 (D) 715 N
 (E) 906 N



10. A 10-kg block is connected to a 40-kg block as shown in the figure. The surface on which the blocks slide is frictionless. A force of 50 N pulls the blocks to the right. What is the magnitude of the tension T in the rope that connects the two blocks?

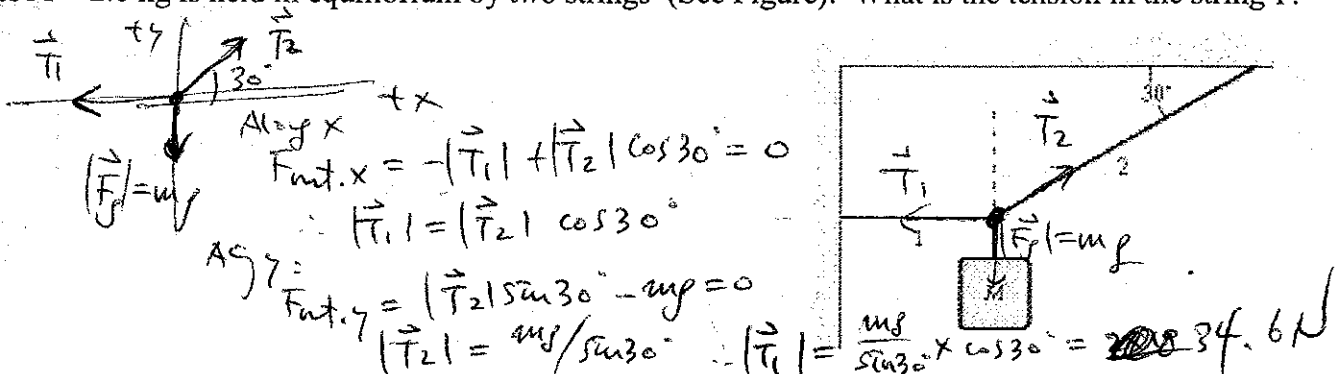


- (A) 0 N
 (B) 10 N
 (C) 20 N
 (D) 40 N
 (E) 50 N



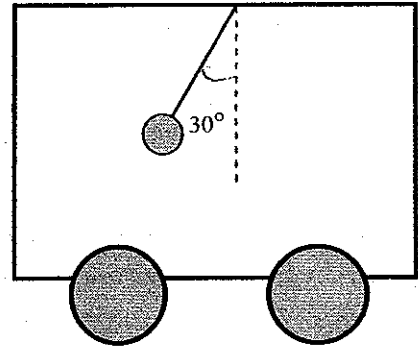
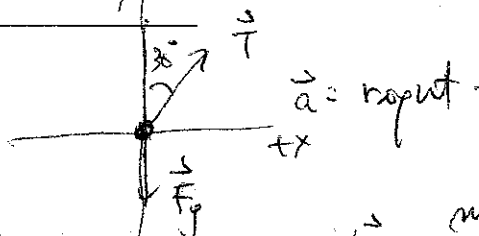
11. A mass $M = 2.0$ kg is held in equilibrium by two strings (See Figure). What is the tension in the string 1?

- A. 12 N
 B. 40 N
 C. 17 N
 D. 30 N
 E. 35 N



12. A 5-kg ball hangs at one end of a string that is attached to a support on a railroad boxcar. When the boxcar accelerates to the right, the rope makes an angle of 30° with the vertical. The acceleration of gravity is 9.8 m/s² and air resistance is negligible. Find the acceleration of the boxcar.

- a. 56.6 m/s²
- b. 49.0 m/s²
- c. 17.0 m/s²
- d. 9.8 m/s²
- e. 5.7 m/s²



$$F_{\text{net},y} = +|T| \cos 30^\circ - mg = 0 \quad \therefore |T| = \frac{mg}{\cos 30^\circ}$$

$$F_{\text{net},x} = +|T| \sin 30^\circ = ma_x$$

$$\therefore a_x = \frac{1}{m} |T| \sin 30^\circ = \frac{1}{m} \cdot \frac{mg}{\cos 30^\circ} \cdot \sin 30^\circ = g \cdot \tan 30^\circ = 5.8 \text{ m/s}^2$$

13. A boy on board a cruise ship drops a 30.0 gram marble into the ocean. If the resistive force proportionality constant is $b = 0.50 \text{ kg/s}$, what is the terminal speed of the marble in m/s?

- a. 0.06
- b. 0.29
- c. 0.45
- d. 0.59
- e. 0.90

$$v_T = \frac{mg}{b} = \frac{30 \times 10^{-3} \times 10}{0.50} = 0.6$$

14. The distance between the Sun and the Earth is about $1.5 \times 10^{11} \text{ m}$. What is the acceleration of the Earth in its circular orbit with the Sun at the center? There are about 365 days in a year.

- a. $6.0 \times 10^{-3} \text{ m/s}^2$
- b. $2.5 \times 10^{-2} \text{ m/s}^2$
- c. $1.5 \times 10^3 \text{ m/s}^2$
- d. $1.9 \times 10^2 \text{ m/s}^2$
- e. $1.1 \times 10^{-1} \text{ m/s}^2$

$$a = \frac{v^2}{r} = \frac{29885^2}{(1.5 \times 10^{11})} = 0.006 \text{ m/s}^2 = 6 \times 10^{-3} \text{ m/s}^2$$

$$v = \frac{2\pi r}{T} = \frac{2\pi \times (1.5 \times 10^{11})}{365 \times 24 \times 60 \times 60} = 29885 \text{ m/s}$$

15. Two blocks with the masses of $m_1 = 8\text{kg}$ and $m_2 = 5\text{kg}$ are connected by a string as shown. Mass m_1 is large enough so that mass m_2 on the table moves to the right. The pulley is massless and frictionless. But the table surface has friction with $\mu_s = 0.3$ and $\mu_k = 0.2$. What is the acceleration of the hanging mass m_1 ?

- A) 8.1 m/s² downward
- B) 5.4 m/s² downward
- C) 9.1 m/s² downward
- D) 10.8 m/s² downward
- E) 2.7 m/s² downward

For m_1 & m_2

$$F_{\text{net},x} = +m_1 g - |f_k| = (m_1 + m_2) a_x$$

$$|f_k| = \mu_k |F_N| = \mu_k m_2 g$$

$$m_1 g - \mu_k m_2 g = (m_1 + m_2) a_x$$

$$a_x = \frac{(m_1 - \mu_k m_2) g}{m_1 + m_2} = \frac{(8 - 0.2 \times 5)}{8 + 5} \times 10$$

$$= +5.4$$

