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This test is closed book except for the notes provided, Show enough work for FULL credit. Attach extra white paper as needed - just indicate such. Each problem is 5 points unless otherwise noted. Multiple choice questions require a brief justification.

Chpt 4: Newton's Laws

① In a collision between a huge SUV and a small hybrid car, the SUV exerts a larger force on the hybrid than the hybrid exerts on the SUV.

5

- A) True
- B) False
- C) It depends on whether the collision is a head-on collision or a rear-end collision.

equal and opposite

② A 75-N box rests on a perfectly smooth horizontal surface. The minimum force need to start the box moving is

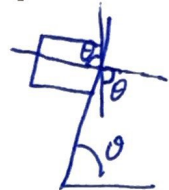
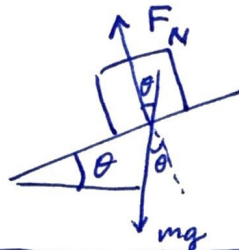
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- A) 750 N.
- B) 75 N.
- C) 7.5 N.
- D) any horizontal force greater than zero.

③ A block of mass m sits at rest on a rough inclined ramp that makes an angle θ with the horizontal. What must be true about normal force F_N on the block due to the ramp?

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- A) $F_N > mg \cos \theta$
- B) $F_N = mg \sin \theta$
- C) $F_N = mg \cos \theta$
- D) $F_N > mg \sin \theta$
- E) $F_N > mg$

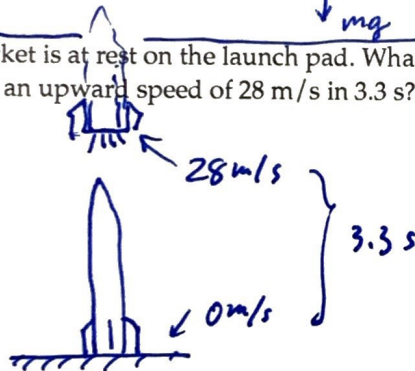


as $\theta \rightarrow 90^\circ$ $F_N \rightarrow 0$ so use $\cos \theta$

④ A 590-kg rocket is at rest on the launch pad. What upward thrust force is needed to accelerate the rocket uniformly to an upward speed of 28 m/s in 3.3 s?

(i) Diagram

2



(ii) Freebody

2



(iii) Equations

2 $\sum F = ma$ $F_T - F_G = ma$

(iv) Solve

4 $F_T = ma + mg$
 $= m [8.48 \text{ m/s}^2 + 9.8 \text{ m/s}^2]$

$a = \frac{v_f - v_i}{\Delta t} = \frac{28 - 0}{3.3} = \underline{\underline{8.48 \text{ m/s}^2}}$

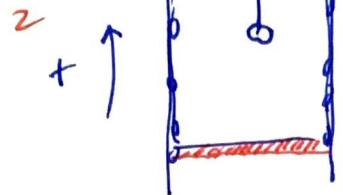
$= 590 \text{ kg} [18.28 \text{ m/s}^2]$

$F_{\text{Thrust}} = 10,788 \text{ N}$

10

5 (10 pts) A 10-kg object is hanging by a very light wire in an elevator that is traveling upward. The tension in the rope is measured to be 75 N. What are the magnitude and direction of the acceleration of the elevator?

(i) Diagram



(ii) Freebody



(iii) Equations

2 $\sum F = ma; F_T - F_G = ma$

(iv) Solve

4 $a = \frac{F_T - F_G}{m}$
 $= \frac{75\text{N} - 98\text{N}}{10\text{kg}}$

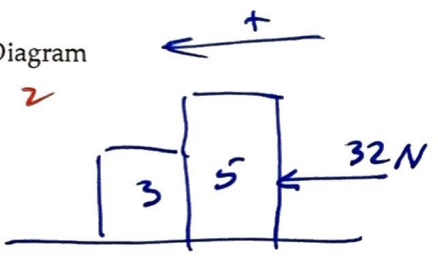
$a = -2.3 \text{ m/s}^2$

The elevator is acc'ln down

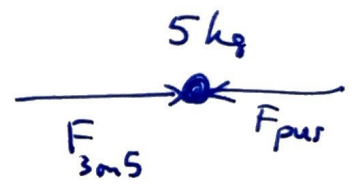
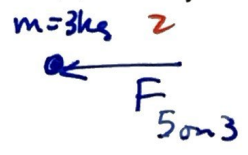
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6 (10 pts) A 3.0-kg and a 5.0-kg box rest side-by-side on a smooth, level floor. A horizontal force of 32 N is applied to the 5.0-kg box pushing it against the 3.0-kg box, and, as a result, both boxes slide along the floor. How hard do the two boxes push against each other? [Hint: Conceptually insert a stiff massless rod between the blocks.]

(i) Diagram



(ii) Freebody



(iii) Equations

2 $F = ma$

$F = ma$

(iv) Solve

4 $a = \frac{F}{M_{\text{tot}}}$
 $= \frac{32\text{N}}{(3+5)\text{kg}}$
 $= \underline{\underline{4 \text{ m/s}^2}}$

So $F_{5\text{on}3} = ma$
 $= (3\text{kg})(4\text{m/s}^2)$

$F = 12\text{N}$

to the left.

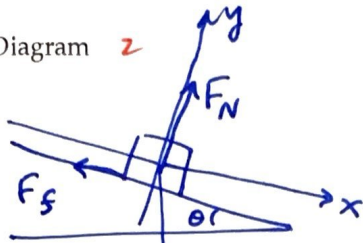
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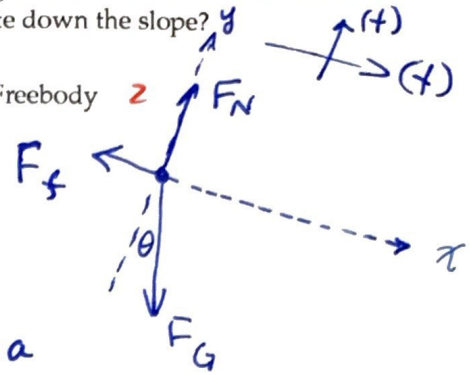
Key

7) (10 pts) A 6.0-kg box slides down an inclined plane that makes an angle of 39° with the horizontal. If the coefficient of kinetic friction is 0.40, at what rate does the box accelerate down the slope?

(i) Diagram 2



(ii) Freebody 2



(iii) Equations 2

$$\sum F = ma : \begin{cases} x: -F_f + F_G \sin \theta = ma \\ y: F_N - F_G \cos \theta = 0 \\ f: F_f = \mu_k F_N \end{cases}$$

(iv) Solve 4

TOP: $-(\mu_k F_G \cos \theta) + F_G \sin \theta = ma$

$-\mu_k mg \cos \theta + mg \sin \theta = ma$

$-(0.4)(9.8 \text{ m/s}^2) \cos(39^\circ) + (9.8 \text{ m/s}^2) \sin(39^\circ) = a$
 $-3.05 \text{ m/s}^2 + 6.167 \text{ m/s}^2 = \boxed{3.12 \text{ m/s}^2}$

Ch 5: Circular Motion and Gravity

8) When an object moves in uniform circular motion, the direction of its acceleration is

- A) is directed away from the center of its circular path.
- B) in the same direction as its velocity vector.
- C) is directed toward the center of its circular path.
- D) depends on the speed of the object.
- E) in the opposite direction of its velocity vector.

change of constant $\Delta \vec{v}$

9) Two cars go around a banked curve at the proper speed for the banking angle. One car has tires with excellent traction, while the other car has bald slippery tires. Which of these cars is more likely to slide on the pavement as it goes around the curve?

- A) Neither car will slide. *No \perp forces to the direction travelling*
- B) the car with the new tires
- C) the car with the bald tires
- D) It depends on if the pavement is wet or dry.

10) Let the orbital radius of a planet be R and let the orbital period of the planet be T . What quantity is constant for all planets orbiting the sun, assuming circular orbits? Why?

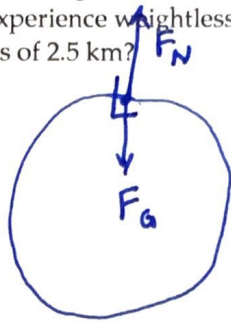
- A) T^3/R^2
- B) T/R
- C) T^2/R^3
- D) T/R^2
- E) T^2/R

Kepler's Law : $T^3/R^3 = \text{const.}$

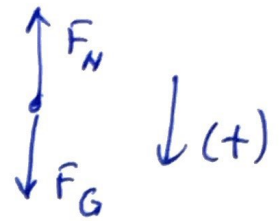
25)

11 (10 pts) In order to simulate weightlessness for astronauts in training, they are flown in a vertical circle. If the seated passengers are to experience weightlessness, how fast should an airplane be moving at the top of a vertical circle with a radius of 2.5 km?

(i) Diagram 2



(ii) Freebody 2



(iii) Equations 2

$$\sum F_{\text{radius}} = ma_c, \quad a_c = v^2/R$$

(iv) Solve 4

10

floating

$$\begin{aligned} -F_N + F_G &= m v^2/R \\ 0 + mg &= m v^2/R \end{aligned}$$

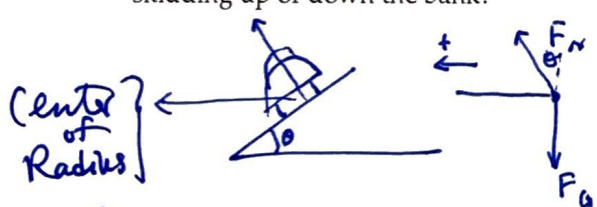
$$v = 156.5 \text{ m/s}$$

$$v = \sqrt{gR}$$

$$v = \sqrt{(9.8 \text{ m/s}^2)(2500 \text{ m})}$$

12 What is the proper banking angle for an Olympic bobsled to negotiate a 100-m radius turn at 35 m/s without skidding up or down the bank?

5



$$\begin{aligned} \sum F_r &= m v^2/r \\ F_N \sin \theta &= m v^2/r \\ F_N \cos \theta &= F_G \end{aligned}$$

$$\frac{F_N \sin \theta}{F_N \cos \theta} = \frac{m v^2/r}{mg}$$

$$\tan \theta = v^2/gr$$

$$\theta = \tan^{-1} \left(\frac{(35 \text{ m/s})^2}{9.8(100)} \right) = 51.3^\circ$$

forgot to put on sheet

13 An astronaut drops a marble on the surface of the airless Planet Z-49 and observes that it accelerates at 7.5 m/s². She also knows that the radius of Z-49 is 3.39 × 10⁶ m. From this information, what will she determine for the mass of Z-49? ($G = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2$)

9

$$\begin{aligned} F_G &= mg \\ G \frac{Mm}{R^2} &= mg \\ M &= \frac{R^2 g}{G} \end{aligned}$$

$$M = \frac{[3.39 \times 10^6 \text{ m}]^2 (7.5 \text{ m/s}^2)}{(6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2)}$$

$$M = 1.21 \times 10^{24} \text{ kg}$$

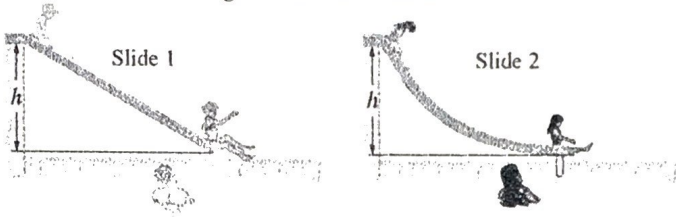
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Ch 7: Work and Energy

- 5 14) A 35-N bucket of water is lifted vertically 3.0 m and then returned to its original position. How much work did gravity do on the bucket during this process?
 A) 45 J B) 180 J C) 900 J D) 90 J E) 0 J

end = start so $\Delta P = 0$

- 5 15) Swimmers at a water park have a choice of two frictionless water slides, as shown in the figure. Although both slides drop over the same height h , slide 1 is straight while slide 2 is curved, dropping quickly at first and then leveling out. How does the speed v_1 of a swimmer reaching the bottom of slide 1 compare with v_2 , the speed of a swimmer reaching the end of slide 2?



$mgh = \frac{1}{2}mv^2$
 ↑ orientation not involved

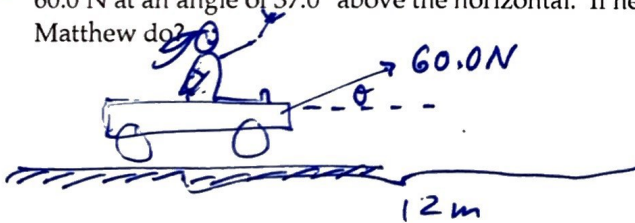
- 5 A) $v_1 = v_2$
 B) $v_1 < v_2$
 C) $v_1 > v_2$
 D) The heavier swimmer will have a greater speed than the lighter swimmer, no matter which slide he uses.
 E) No simple relationship exists between v_1 and v_2 .

- 5 16) Joe and Bill throw identical balls vertically upward. Joe throws his ball with an initial speed twice as much as Bill. If there is no air resistance, the maximum height of Joe's ball will be

- A) roughly 1.4 times that of Bill's ball.
 B) four times that of Bill's ball.
 C) two times that of Bill's ball.
 D) eight times that of Bill's ball.
 E) equal to that of Bill's ball.

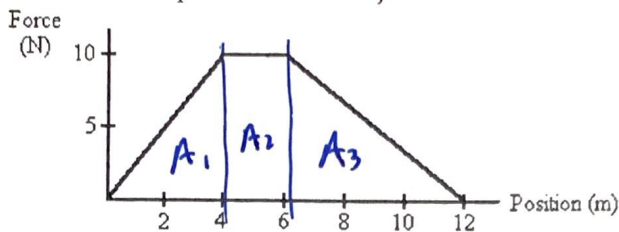
$mgh = \frac{1}{2}mv^2$
 $h = \frac{v_0^2}{2g}$
 $h_J = \frac{(2v_0)^2}{2g}$
 $h_B = h_J / 4$

- 5 17) Matthew pulls his little sister Sarah along the horizontal ground in a wagon. He exerts a force on the wagon of 60.0 N at an angle of 37.0° above the horizontal. If he pulls her a distance of 12.0 m, how much work does Matthew do?



$W = Fd \cos \theta$
 $= (60.0 \text{ N})(12 \text{ m}) \cos 37^\circ$
 $= 575.0 \text{ N}\cdot\text{m}$
 $= \boxed{575 \text{ J}}$

- 18) A force acts on an object, causing it to move parallel to the force. The graph in the figure shows this force as a function of the position of the object. How much work does the force do as the object moves from 6 m to 12 m?



$$W_1 = F \cdot d$$

← changes

$$= \frac{1}{2} \text{Base} \cdot \text{Height}$$

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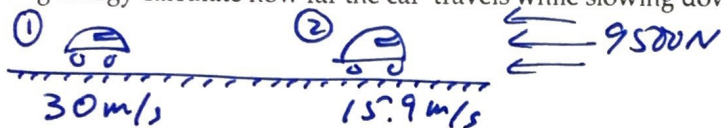
So

$$W = W_1 + W_2 + W_3$$

$$= \frac{1}{2}(4-0\text{m})(10\text{N}) + (6-4\text{m})(10) + \frac{1}{2}(12-6\text{m})(10)$$

$$= 20\text{J} + 20\text{J} + 30\text{J} = 70\text{J} \text{ total Work}$$

- 19) A 1000-kg car experiences an opposing net force of 9500 N while slowing down from 30 m/s to 15.9 m/s. Using energy calculate how far the car travels while slowing down?



5

$$E_1 - W = E_2$$

$$E_1 - E_2 = W$$

$$\frac{1}{2} m v_1^2 - \frac{1}{2} m v_2^2 = F \cdot d$$

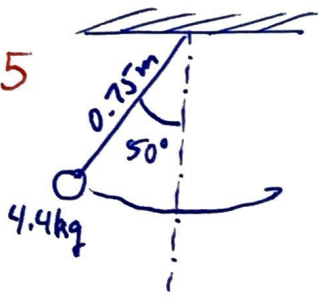
$$\frac{1}{2} \frac{m}{F} (v_1^2 - v_2^2) = d$$

$$d = \frac{(1000\text{kg})}{2 \cdot 9500\text{N}} (30^2 - 15.9^2) \frac{\text{m}^2}{\text{s}^2} = 34.05\text{m}$$

- 20) A frictionless simple pendulum, with a small but dense 4.4-kg mass at the end and a length of 75 cm, is released from rest at an angle of 50° with the vertical.

- (a) To what height above its lowest point does the mass swing on the other side?
 (b) What is the speed of the mass at the bottom of the swing?

5



(a) same height as beginning height.

which is $0.75\text{m} - 0.75 \cos 50^\circ = 0.2679\text{m}$
 or 27cm

(b) $mgh = \frac{1}{2}mv^2$

$$v = \sqrt{2gh}$$

$$v = \sqrt{2(9.8\text{m/s}^2)(0.27\text{m})}$$

$$v = 2.30\text{m/s}$$

(a)

