

PH2100 Exam III

SPRING 2005

INSTRUCTIONS

1. Remove the answer sheet (General Purpose Data Sheet I) from the exam booklet.
2. Using a #2 pencil, write your first and last name neatly in the NAME box.
3. Under the green box labeled "ID NUMBER", write in your MTU student I.D. number (without dashes) and carefully fill in the appropriate circles corresponding to your ID number. Most of you have your Social Security number as your student I.D. number. If your M number is your student I.D. number, please replace the leading M with a zero. Again, do not include dashes. Leave the "SPECIAL CODES" boxes blank.
4. Be sure to fill in the circles completely and avoid stray marks on the form.
5. This a ninety minute exam.
6. Please cover your Score Sheet at all times.
7. This is a closed book exam. You may use the PH2100 Formula Sheet that is attached to this exam, and you may find it convenient to rip the formula sheet from the exam booklet.
8. Equations may not be stored in calculators, nor may calculators be exchanged.
9. Assume all numerical data supplied with the problems have three significant figure accuracy, unless explicitly identified otherwise.
10. This exam consists of a total of 31 questions on seven following pages: each question is worth five points. Problem 31 is a five-point bonus question. The total number of points available on the exam is 155, out of which 5 points can be considered bonus points.
11. If you have any questions during the exam, please raise your hand and wait for assistance.
12. Please turn in only your answer sheet. You may keep the exam booklet and formula sheet.

The following information pertains to the next five questions:

A ladybug sits at the outer edge of a merry-go-round of radius 2.5 m, and a gentleman bug sits halfway between her and the axis of rotation. The merry-go-round starts from rest, and accelerates uniformly such that after 30 seconds it rotates at a rate of 2.0 revolutions per minute.

1. At any given instant in time, the gentleman bug's velocity is

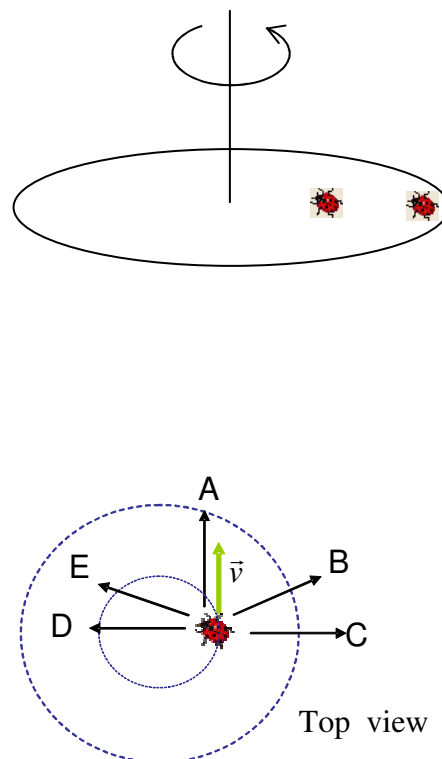
(A) half the ladybug's.
 (B) the same as the ladybug's.
 (C) $\sqrt{2}$ times the ladybug's.
 (D) twice the ladybug's.

2. During the first 30 seconds of motion, the angular acceleration of the ladybug is

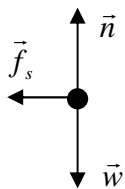
(A) $8.55 \times 10^{-4} \text{ rad/s}^2$
 (B) $3.12 \times 10^{-3} \text{ rad/s}^2$
 (C) $6.98 \times 10^{-3} \text{ rad/s}^2$
 (D) $1.40 \times 10^{-2} \text{ rad/s}^2$
 (E) $2.76 \times 10^{-2} \text{ rad/s}^2$

3. During the first 30 seconds of motion, the direction of the acceleration of the gentleman bug, according to the diagram at the right is

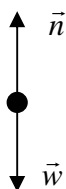
(A) A
 (B) B
 (C) C
 (D) D
 (E) E



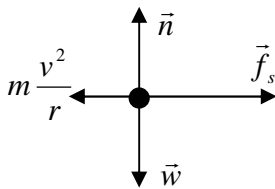
4. While the merry-go-round rotates at a constant angular velocity, which of the following is a correct free body diagram for the ladybug? Take the positive radial direction to be to the left in the side-views below.



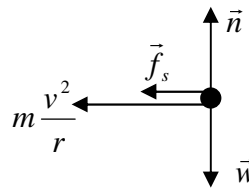
(A)



(B)



(C)



(D)

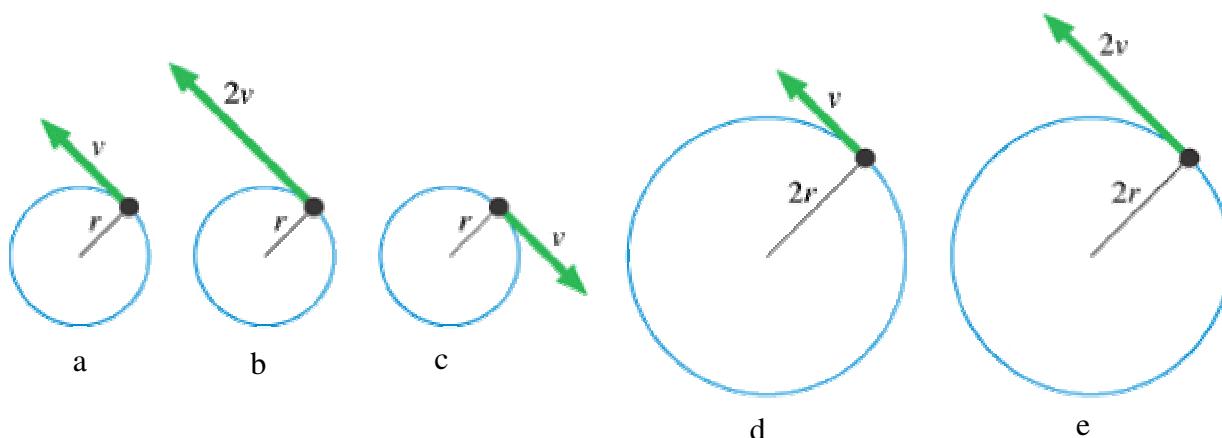
5. Should the merry-go-round continue to increase its angular velocity with time, which bug would slide off first?

(A) The gentleman bug.
 (B) The ladybug.
 (C) Both bugs would slide off at the same time.

6. If you swing a bucket of water fast enough in a vertical circle, at the highest point the water does not spill out because an upward force on the water balances the pull of gravity on the water.

(A) True
 (B) False

7. Rank in order, from largest to smallest, the centripetal accelerations $(a_r)_a$ to $(a_r)_e$ of particles a to e below.



- (A) $(a_r)_b > (a_r)_e > (a_r)_a > (a_r)_d > (a_r)_c$
 (B) $(a_r)_b = (a_r)_e > (a_r)_a = (a_r)_c > (a_r)_d$
 (C) $(a_r)_b > (a_r)_a = (a_r)_c = (a_r)_e > (a_r)_d$
 (D) $(a_r)_b > (a_r)_a = (a_r)_c > (a_r)_e > (a_r)_d$
 (E) $(a_r)_b > (a_r)_e > (a_r)_a = (a_r)_c > (a_r)_d$

8. A ball attached to a string is swung in a vertical circle. As the ball passes through its topmost point, the tension in the string

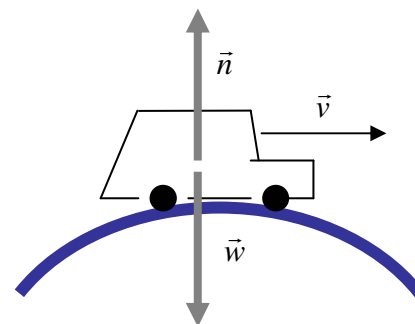
- (A) could be less than, equal to, or greater than the weight of the ball.
 (B) is always less than the weight of the ball.
 (C) is always equal to the weight of the ball.
 (D) is always greater than the weight of the ball.

The following information pertains to the next two problems:

A car of weight w is rolling over the top of a hill at speed v and with a tangential acceleration $a_t > 0$.

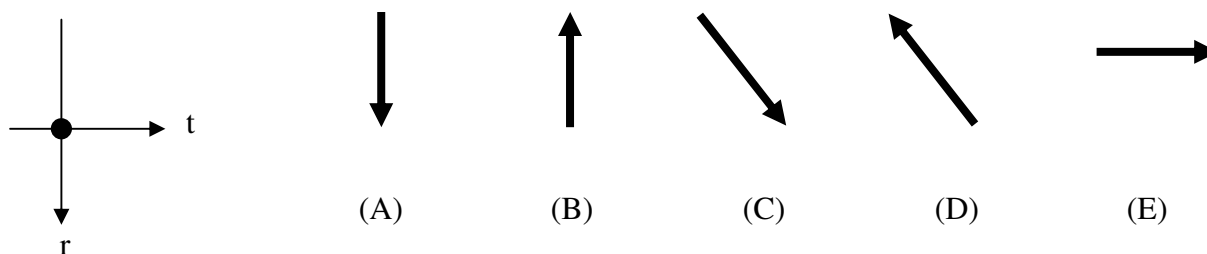
9. At this instant,

- (A) $n > w$
 (B) $n < w$
 (C) $n = w$
 (D) We cannot compare n and w without knowing v .



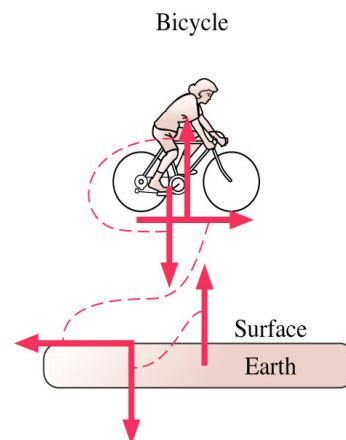
(vectors not drawn to scale)

10. What is the representative direction of the total acceleration of the car at the instant shown, with respect to the coordinate system shown?



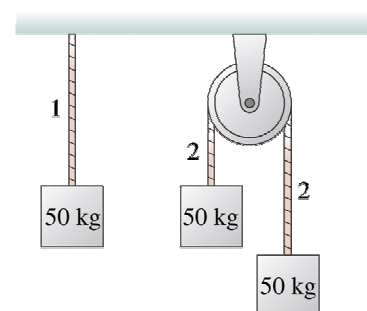
11. What, if anything, is wrong with the force diagram for a bicycle that is accelerating toward the right?

- (A) It does not draw each object separately.
- (B) It draws interactions between one body and itself.
- (C) It fails to identify all relevant forces.
- (D) Nothing is wrong.



12. All three 50 kg blocks are at rest. The pulley is massless and frictionless. Is the tension in rope 2 greater than, less than or equal to the tension in rope 1?

- (A) greater than
- (B) less than
- (C) equal to



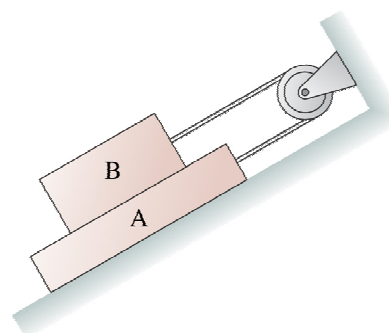
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13. A large truck moving at 55 mi/h collides head-on with a vertically-falling drop of rain on the front bumper. During the collision

- (A) the truck exerts a force on the drop, but the drop exerts no force on the truck.
- (B) the truck exerts a smaller amount of force on the drop than the drop exerts on the truck.
- (C) the truck exerts the same amount of force on the drop as the drop exerts on the truck.
- (D) the truck exerts a greater amount of force on the drop than the drop exerts on the truck.

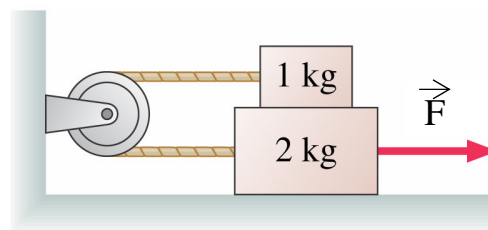
14. For the figure at the right, how many forces would be shown acting on block A in a proper free body diagram if all the contacting surfaces have friction?

- (A) 3
- (B) 4
- (C) 5
- (D) 6
- (E) 7



15. The 2-kg block rests on a tabletop and the 1-kg mass rests on top of the 2-kg mass, as shown. The surfaces between the two blocks as well as the 2-kg block and the table have coefficients of friction $\mu_s=0.300$ and $\mu_k=0.250$. What is the maximum applied force F on the 2-kg block such that the blocks remain at rest?

- (A) 3.00 N
- (B) 5.66 N
- (C) 7.19 N
- (D) 13.1 N
- (E) 14.7 N

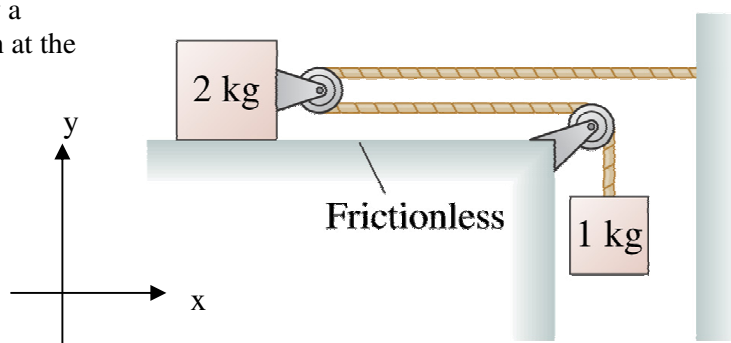


The following information pertains to the next three problems.

Two masses, $m_1 = 1.0$ kg and $m_2 = 2.0$ kg are connected by a massless string by frictionless, massless pulleys as shown at the right.

16. What is the acceleration constraint?

- (A) $(a_1)_y = -2(a_2)_x$
- (B) $(a_1)_y = -(a_2)_x$
- (C) $(a_1)_y = (a_2)_x/2$
- (D) $(a_1)_y = (a_2)_x$
- (E) $(a_1)_y = 2(a_2)_x$



17. What is the tension in the rope?

- (A) 3.27 N
- (B) 6.54 N
- (C) 10.2 N
- (D) 12.2 N
- (E) 13.0 N

18. What is the magnitude of the acceleration of m_2 ?

- (A) 12.2 m/s^2
- (B) 10.6 m/s^2
- (C) 9.80 m/s^2
- (D) 3.27 m/s^2
- (E) 1.68 m/s^2

19. A planet has 4 times the mass of the earth, but the acceleration due to gravity on the planet's surface is the same as on the earth's surface. The planet's radius is

- (A) $\frac{1}{4}R_e$
- (B) $\frac{1}{2}R_e$
- (C) R_e
- (D) $2R_e$
- (E) $4R_e$

20. Which one of the following is NOT one of Kepler's laws of planetary motion?

- (A) Planets move in nearly circular orbits around the sun.
- (B) An imaginary line extending from the planet to the sun sweeps out equal areas during equal time intervals.
- (C) The square of the orbital period for a planet to move around the sun is proportional to the cube of its distance from the sun (semimajor axis length).

The following information pertains to the next two questions:

Jupiter has a volcanic moon called Io that is 4.22×10^8 m from Jupiter's center and takes 1.75 days to go around the planet. Another of Jupiter's moons, Europa, is 6.71×10^8 m away. Assume the orbits are circular.

21. What is the magnitude of Io's acceleration in its orbit around Jupiter?

- (A) 0.0991 m/s^2
- (B) 0.150 m/s^2
- (C) 0.337 m/s^2
- (D) 0.664 m/s^2
- (E) 0.729 m/s^2

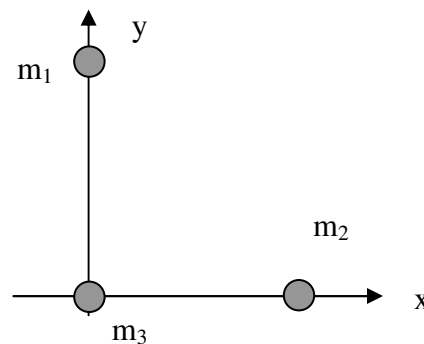
22. How many days does it take Europa to go around Jupiter once?

- (A) 3.51 days
- (B) 1.75 days
- (C) 0.550 days
- (D) 6.25 days
- (E) 54.2 days

23. Three 200-kg masses are arranged as shown in the diagram at the right.

Masses m_1 and m_2 are both 0.250 m from the origin. What is the magnitude of the gravitational force on m_3 due to the other two masses?

- (A) $4.78 \times 10^{-8} \text{ N}$
- (B) $1.46 \times 10^{-5} \text{ N}$
- (C) $3.32 \times 10^{-5} \text{ N}$
- (D) $6.71 \times 10^{-5} \text{ N}$
- (E) $7.11 \times 10^{-4} \text{ N}$

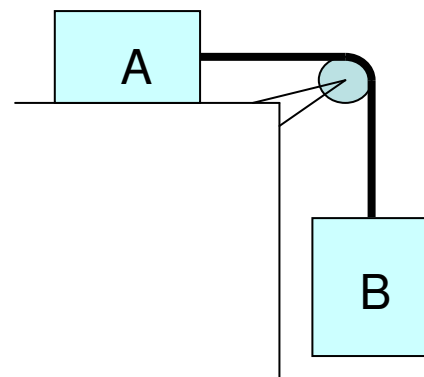


24. What is the "principle of equivalence" described in the textbook?

- (A) When two objects are connected by a massless string, the tension action by the rope on each object is of the same magnitude, "as if" the forces were action-reaction pairs.
- (B) The normal force on an object is equivalent to its weight.
- (C) Two objects interacting exert forces with equal magnitudes but opposite in direction.
- (D) An object's inertial mass is equivalent to its gravitational mass.

The following information pertains to the next two questions:

Block A sits at rest on a frictionless surface, held in place by someone's hand (not shown), while block B is hanging.



25. If the hand were removed, the tension in the string would

- (A) decrease.
- (B) stay the same.
- (C) increase.
- (D) No conclusion can be made about the tension without knowing the masses of the blocks.

26. If the hand were removed, the acceleration of block B would be

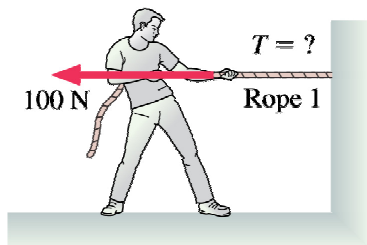
- (A) equal to 9.8 m/s^2 .
- (B) less than 9.8 m/s^2 .
- (C) greater than 9.8 m/s^2 .

The following information and pictures (a) and (b) below pertain to the next two questions.

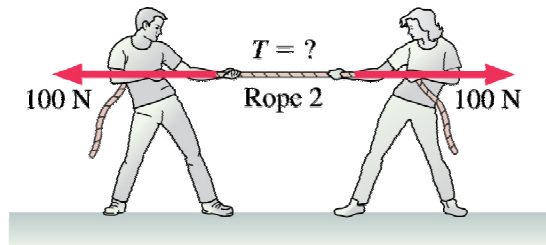
In figure (a) the physics student pulls on the massless rope, which is attached to the wall, with a pulling force of 100 N.

In figure (b) the physics student is pulling on the massless rope with a 100 N force, while a chemistry student is pulling on the other end of the rope, also with a 100 N force.

(a)



(b)



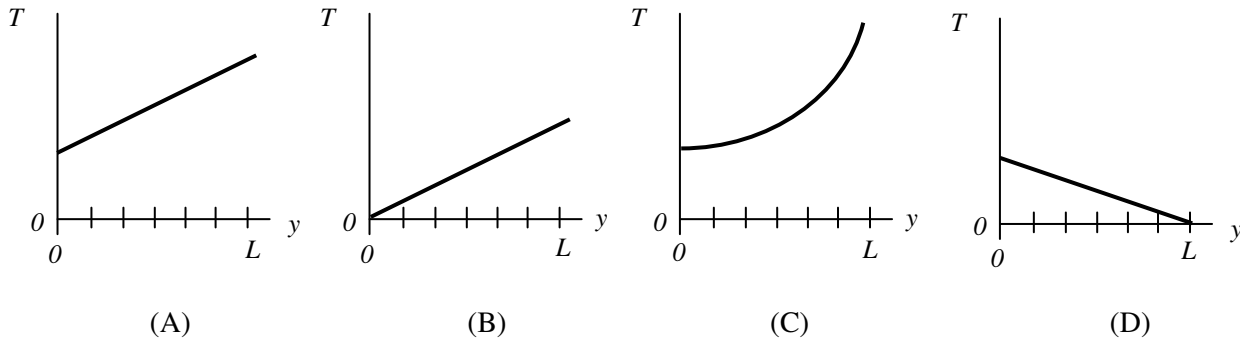
27. Is the tension in the rope in figure (a)

- (A) less than
 - (B) equal to
 - (C) greater than
- the tension in the rope in figure (b).

28. What is the tension in the middle of the rope in figure (b) ?

- (A) 0.00 N
- (B) 50.0 N
- (C) 100. N
- (D) 200. N

29. A uniform steel cable of length L is hanging vertically down a mine shaft. At the end of the cable hangs an empty ore car. Taking into account that both the ore car and the steel cable have mass, which of the following graphs represents the tension T in the steel cable as a function of the height y above the ore car?

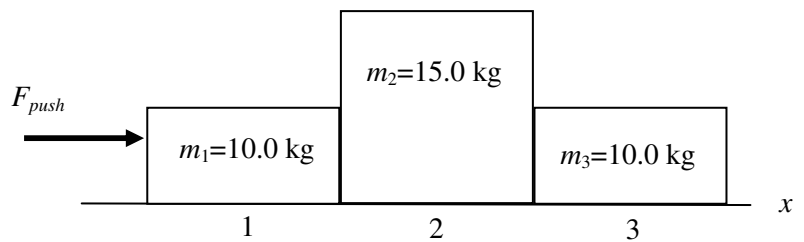


The following information pertains to the last two questions:

Three blocks of masses $m_1 = m_3 = 10.0$ kg and $m_2 = 15.0$ kg are being pushed on a smooth, horizontal floor as shown in the diagram, by a force $F_{push} = 15.0$ N applied to Block 1.

30. What is the acceleration of Block 3?

- (A) 9.80 m/s^2
 (B) 6.67 m/s^2
 (C) 1.23 m/s^2
 (D) 0.824 m/s^2
 (E) 0.429 m/s^2



31. **BONUS:** What is the normal force exerted on Block 2 by Block 1?

- (A) -3.75 N
 (B) -4.44 N
 (C) -9.89 N
 (D) -10.7 N
 (E) -12.1 N