Last Name:_____First Name_____Network-ID_____
Discussion Section:_____Discussion TA Name:_____

Instructions—
Turn off your cell phone and put it away.
This is a closed book exam. You have ninety (90) minutes to complete it.

1. Use a #2 pencil; do **not** use a mechanical pencil or a pen. Fill in completely (until there is no white space visible) the circle for each intended input – both on the identification side of your answer sheet and on the side on which you mark your answers. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner.

2. Print your last name in the **YOUR LAST NAME** boxes on your answer sheet and print the first letter of your first name in the **FIRST NAME INI** box. Mark (as described above) the corresponding circle below each of these letters.

3. Print your NetID in the **NETWORK ID** boxes, and then mark the corresponding circle below each of the letters or numerals. Note that there are different circles for the letter "I" and the numeral "1" and for the letter "O" and the numeral "0". **Do not** mark the hyphen circle at the bottom of any of these columns.

4. **This Exam Booklet is Version A**. Mark the **A** circle in the **TEST FORM** box at the bottom of the front side of your answer sheet.

5. Stop **now** and double-check that you have bubbled-in all the information requested in 2 through 4 above and that your marks meet the criteria in 1 above. Check that you do not have more than one circle marked in any of the columns.

6. Do **not** write in or mark any of the circles in the STUDENT NUMBER or SECTION boxes.

7. On the **SECTION** *line*, print your **DISCUSSION SECTION**. (You need not fill in the COURSE or INSTRUCTOR lines.)

8. Sign **(DO NOT PRINT)** your name on the **STUDENT SIGNATURE** *line*.

Before starting work, check to make sure that your test booklet is complete. You should have 13 ***numbered pages*** *plus two Formula Sheets.*

Academic Integrity—**Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including dismissal from the University.**

Exam Grading Policy—
The exam is worth a total of more than 100 points, and will be scaled to 100 points. It is composed of three types of questions:

MC5: *multiple-choice-five-answer questions, each worth 6 points.*
Partial credit will be granted as follows.
(a) If you mark only one answer and it is the correct answer,
you earn **6** points.
(b) If you mark *two* answers, one of which is the correct answer,
you earn **3** points.
(c) If you mark *three* answers, one of which is the correct answer, you earn **2** points.
(d) If you mark no answers, or more than *three*, you earn 0 points.

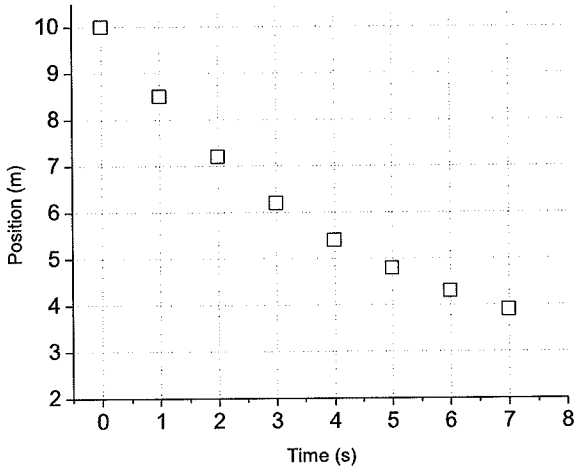
MC3: *multiple-choice-three-answer questions, each worth 3 points.*
No partial credit.
(a) If you mark only one answer and it is the correct answer,
you earn **3** points.
(b) If you mark a wrong answer or no answers, you earn **0** points.

TF: *true-false questions, each worth 2 points.*
No partial credit.

(a) If you mark only one answer and it is the correct answer, you earn **2** points.
(b) If you mark the wrong answer or neither answer, you earn **0** points.

Unless told otherwise, you should assume that the acceleration of gravity near the surface of the earth is 9.8 m/s^2 *downward and ignore any effects due to air resistance.*

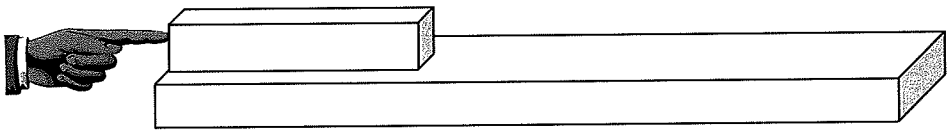
A position of a cart was measured as a function of time every second and is shown below.



1. The average acceleration between 0 and 7 seconds is

a. zero
b. negative
(c.) positive

The following 2 questions concern the same physical situation:
A steel block of mass 1.5 kg is sitting atop a table with coefficient of static friction μ_s = 0.35 and coefficient of kinetic friction μ_k = 0.25. Professor Halfpap is pushing the block as shown in the figure.



2. If the block is at rest, how hard can he push on the block before it will start moving?

a. 2.0 N
b. 4.1 N
c. 5.7 N
(d.) 5.1 N
e. 13.9 N

$$F = \mu_s N = \mu_s mg$$
$$= 0.35 \times 1.5\ kg \times 9.8\ m/s^2$$
$$= 5.14\ N$$

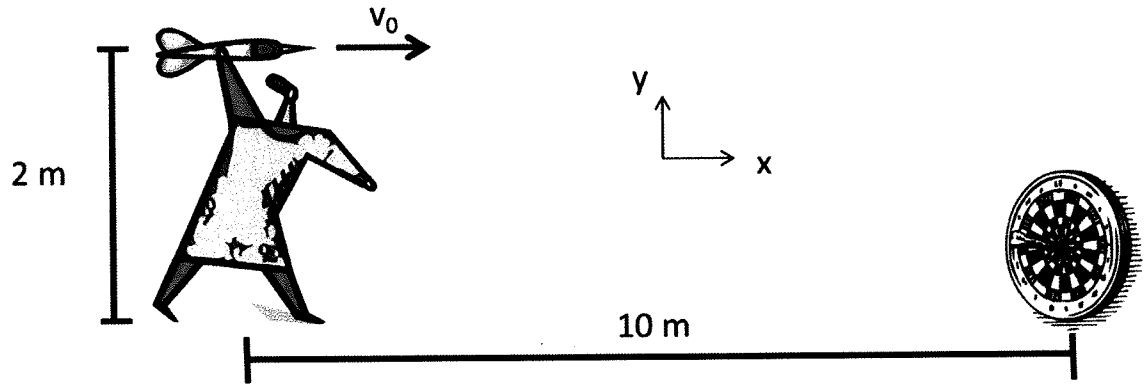
3. Once the book is traveling at 4 m/s, he stops pushing. How much farther does the book move before coming to rest?

a. 6.6 m
(b.) 3.3 m
c. 2.3 m
d. 1.5 m
e. 1.2 m

$$F_K = \mu_K N = \mu_K mg$$
$$a = \frac{F_K}{m} = \frac{\mu_K mg}{m} = \mu_K g = 0.25 \times 9.8\ m/s^2 = 2.45\ m/s^2$$
$$v^2 = v_0^2 - 2a\Delta x \quad (v = 0)$$
$$\Delta x = \frac{v_0^2}{2a} = \frac{(4\ m/s)^2}{2 \times 2.45\ m/s^2} = 3.265\ m$$

The following 2 questions concern the same physical situation:

A person is throwing a dart from a height of 2 m relative to the ground and with the initial velocity of v_0 horizontally (i.e. in the positive x direction). The dart hits the bull's eye of the dart board 0.25 second later. Please ignore air resistance. The drawing is NOT to scale.



4. What is the magnitude of the initial velocity v_0?

a. 20 m/s
b. 30 m/s
(c.) 40 m/s

$d = v_0 t$

$v_0 = d/t = \frac{10\ m}{0.25\ s} = 40\ m/s$

5. What is the height of the bull's eye relative to the ground?

(a.) 1.7 m
b. 1.5 m
c. 1.3 m

$y = y_0 - \cancel{v_{0y}^{=0}} t - \frac{1}{2} g t^2$

$= 2m - \frac{1}{2} 9.8\ m/s^2 \times (0.25s)^2$

$= 1.69\ m$

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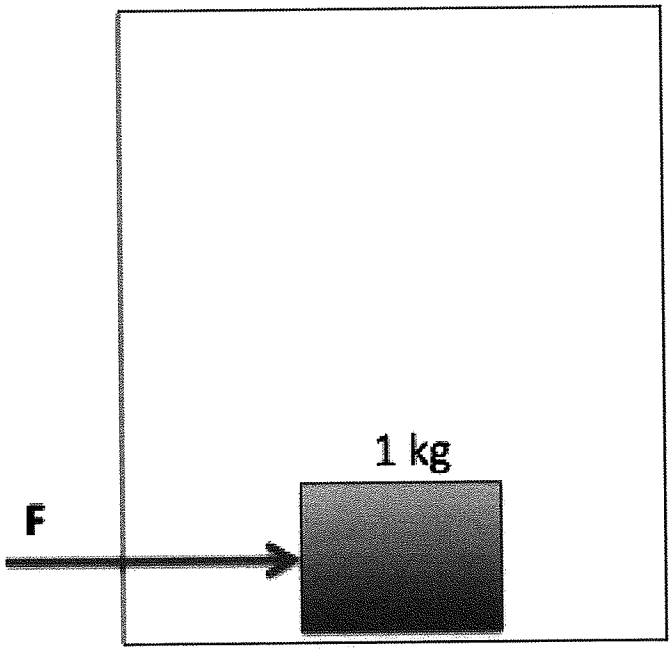
6. In another galaxy, a solar system similar to our own contains a planet that has the same mass as Earth, but it is made of a less dense rock, so its radius is 1.3 times the Earth's radius. How much would a 80 kg person weigh on the surface of that planet? The mass of Earth is 5.9742×10^{24}kg and the radius of Earth is 6.378×10^3 km.

a. 175 N
b. 464 N
c. 603 N
d. 784 N
e. 1019 N

NOT ON EXAM 1

The following 2 questions concern the same physical situation:

There is a box of chocolates with the total mass of 1 kg is sitting on the floor of an elevator. When the elevator is at rest, it takes a horizontal force of 4 N to make the box start to slide.



7. The elevator is now moving vertically at a constant speed. It takes 4 N of horizontal force to make the box start to slide. What can you say about the direction of elevator's motion?

a. It is going up.
b. It is going down.
(c.) Not enough information is given to determine in which direction the box is moving.

8. Now the elevator is accelerating vertically upward by 3 m/s^2. What is the minimum horizontal force on the box required to make the box start to slide?

(a.) 5.22 N
b. 4.6 N
c. 4 N
d. 3.4 N
e. 2.78 N

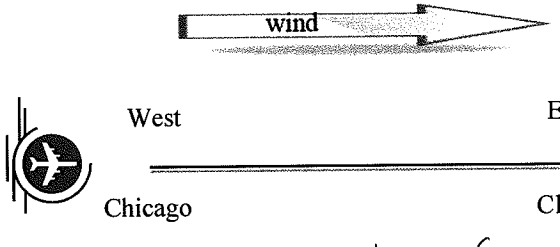
$F = \mu_s N = \mu_s mg \Rightarrow \mu_s = F/mg = \frac{4\ N}{1\ kg \times 9.8\ m/s^2} = 0.41$

With accelerating elevator,

$N = mg + ma = m(g+a) = 1\ kg\ (9.8 + 3)\ m/s^2 = 12.8\ N$

$F = \mu_s N = 0.41 \times 12.8\ N = 5.248\ N$

9. An airplane is flying in the direction from ***west to east*** at the speed of 200 m/s ***relative to the air*** as shown. The wind is blowing at 30 m/s toward east relative to the ground. If it takes 1.5 hour to fly from Chicago to Cleveland under this condition, how long will it take to fly from Cleveland to Chicago under the same condition? Assume that the two cities have the same latitude



a. 1.3 hour
(b.) 2.0 hour
c. 1.7 hour
d. 1.85 hour
e. 1.6 hour

$d = (v_p + v_{air})\,t = (200\ m/s + 30\ m/s)\ 1.5\ hr$

$= 345\ m \times hr/s$

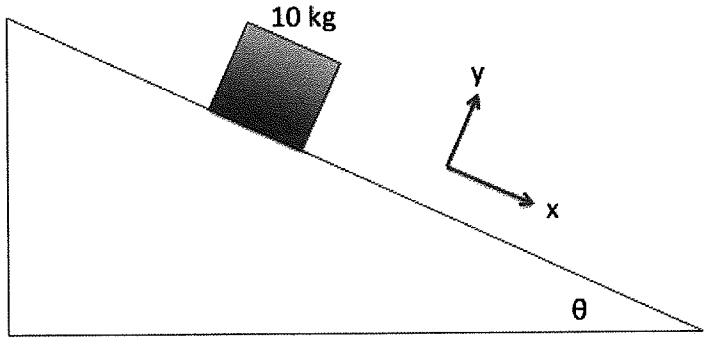
Return trip

$d = (v_p - v_{air})\,t$

$\Rightarrow t = \frac{d}{v_p - v_{air}} = \frac{345\ m \times hr/s}{(200-30)\ m/s} = 2.029\ hr$

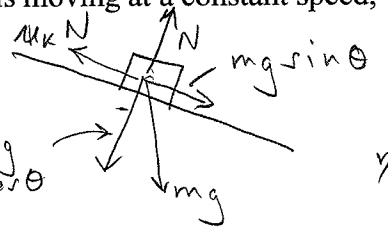
The following 3 questions concern the same physical situation:

A block of mass 10 kg is on the slope making an angle θ with the horizontal direction. The kinetic coefficient of friction is 0.2 and the static coefficient of friction is 0.5 between the block and the sloped wedge. Gravitational force is acting toward the bottom of this page.



10. If the block is moving at a constant speed, what is the angle θ?

a. 10.1°
(b.) 11.3°
c. 12.5°
d. 13.1°
e. 15.5°



$N = mg\cos\theta$

$mg\sin\theta - \mu_K N = ma = 0$

$mg\sin\theta = \mu_K mg\cos\theta$

$\tan\theta = \mu_K$

$\theta = \tan^{-1} 0.2 = 11.3°$

11. Now if the angle θ is increased to 40°, what is the acceleration of the block in the x-direction as defined in the diagram above?

a. 2.9 m/s^2
b. 3.2 m/s^2
c. 4.0 m/s^2
(d.) 4.8 m/s^2
e. 5.3 m/s^2

$mg\sin\theta - \mu_K mg\cos\theta = ma$

$a = g(\sin\theta - \mu_K\cos\theta)$

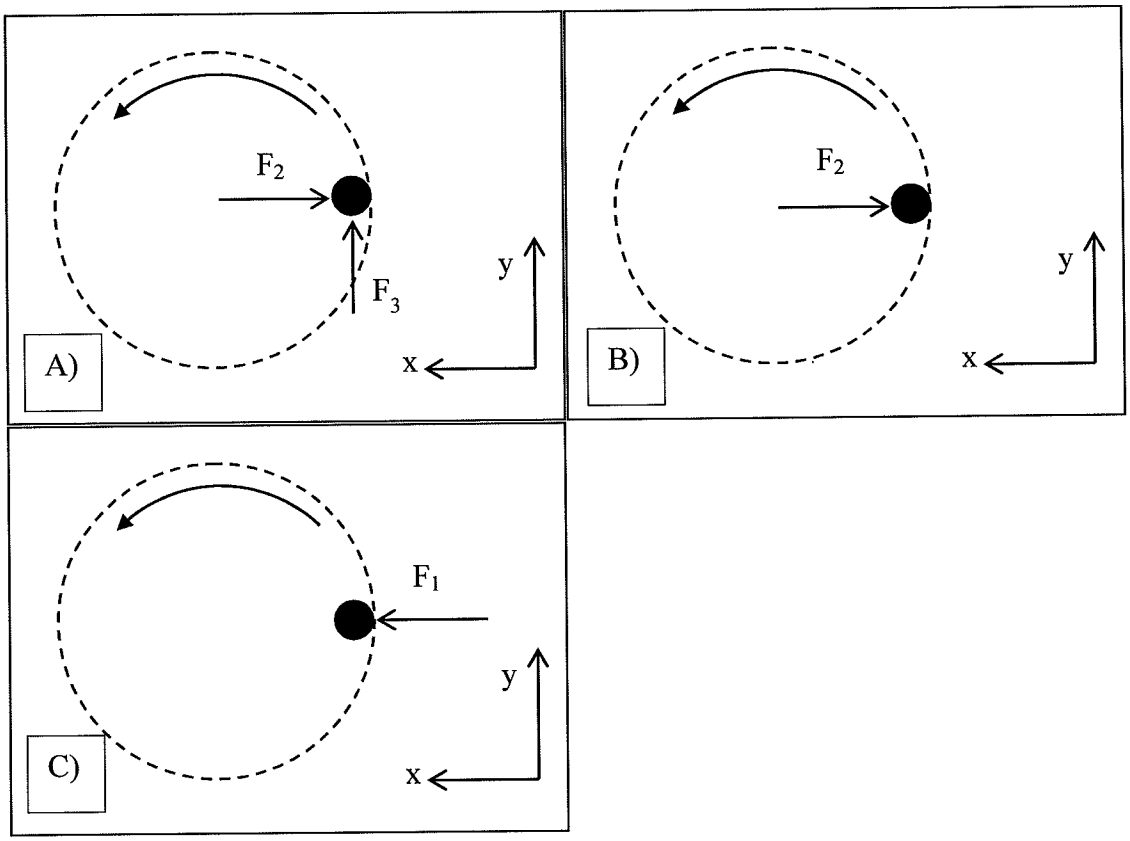
$= 9.8\ m/s^2\ (\sin 40 - 0.2\cos 40)$

$= 4.8\ m/s^2$

12. The mass of the block is now doubled to 20 kg. What is the new acceleration of the block?

a. 9.6 m/s^2
(b.) 4.8 m/s^2
c. 2.4 m/s^2

13. A person sits on the outside end of a bench seat on a merry-go-round (MGR). Below, there are three overhead views of the person on the MGR. The indicated forces are all in the horizontal direction only; no vertical forces are shown. The MGR spins at a constant angular velocity. Which force diagram is correct for the horizontal directions?



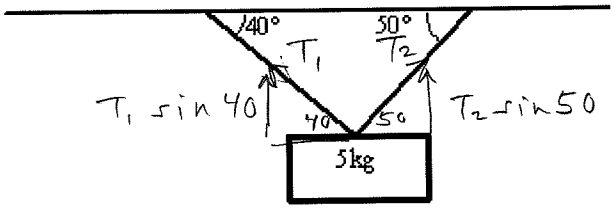
a. Figure A
b. Figure B
c. Figure C

14. A planet has a moon that orbits in a circle at a distance of $1.00 \cdot 10^8$m. The moon's speed is 929.9km/hr. What is the mass of the planet?

a. $3.87 \cdot 10^{20}$kg
b. $1.00 \cdot 10^{23}$kg
c. $1.00 \cdot 10^{31}$kg

NOT ON EXAM 1

15. A mass is hanging from a ceiling by two strings as shown. Find the tension in the right string.



x: $T_1 \cos 40 = T_2 \cos 50$

y: $T_1 \sin 40 + T_2 \sin 50 = mg$

Find T_2:

$T_1 = T_2 \dfrac{\cos 50}{\cos 40}$

$T_2 \dfrac{\cos 50}{\cos 40} \sin 40 + T_2 \sin 50 = 5\,kg \times 9.8\,m/s^2$

$T_2 (0.539 + 0.766) = 49\,N \Rightarrow T = 37.5\,N$

(a.) 37.5N
b. 49.0N
c. 75.0N

16. Two masses are placed against each other on a frictionless surface. A force of 200 N is applied to the box on the left as shown. What is the size of the force exerted on the 5kg block by the 15kg block?

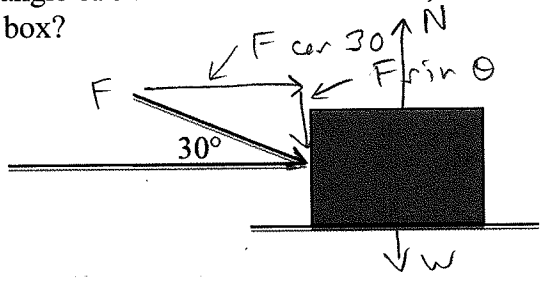
$F = ma \Rightarrow a = F/m = \dfrac{200\,N}{(15+5)\,kg} = 10\,m/s^2$

$F' \rightarrow [5]$

$F' = ma = 5\,kg \times 10\,m/s^2 = 50\,N$

a. 200N
b. 150N
(c.) 50N

17. A 1000N box sits on a flat floor. The coefficient of static friction is 0.5. If you push on the box at an angle of 30° below the horizontal, what is the ~~maximum~~ minimum force needed to start moving the box?



$N = W + F\sin\theta$

$F\cos\theta = \mu_s N = \mu_s (W + F\sin\theta)$

$F(\cos\theta - \mu_s \sin\theta) = \mu_s W$

$F(0.866 - 0.5 \times 1/2) = 0.5 \times 1000\,N$

$F = 812\,N$

a. 406N
b. 500N
(c.) 812N

The next three questions relate to the following description of a moving wheel.

A wheel is rolling on a horizontal surface. It begins with an angular speed of 10rad/s and slows down uniformly until it stops. It is 0.75m in radius and it took 10.0s to stop.

18. Through how many radians did the wheel turn?

$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{-10\ rad/s}{10\ s} = -1\ rad/s^2$

a. 10
(b.) 50
c. 100

$\theta = \theta_0 + \omega_0 t - \frac{1}{2}\alpha t^2$ ($\theta_0 = 0$)

$= 10\ rad/s \times 10\ s - \frac{1}{2} 1\ rad/s^2 \times (10\ s)^2$

$= 50\ rad$

19. How fast was the center of the wheel moving after 5.0s?

$\omega = \omega_0 - \alpha t$

$= 10\ rad/s - 1\ rad/s^2 \times 5\ s$

$= 5\ rad/s$

a. 0.00m/s
(b.) 3.75m/s
c. 5.00m/s

$v = \omega r = 5\ rad/s \times 0.75\ m = 3.75\ m/s$

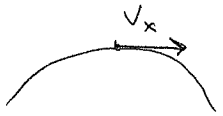
20. How fast was the bottom of the wheel (the part touching the ground) moving after 7.0s?

(a.) 0.00m/s
b. 3.00m/s
c. 2.25m/s

The following 2 questions concern the same physical situation:

A football player passes the ball. The ball leaves his hand and is caught 1.7 seconds later by a receiver 30 meters away. Assume the ball was caught at the same height from which it was thrown.

21. What is the speed of the ball when it is at the top of its trajectory? ← $= v_x$



a. 0 m/s
(b.) 17.6 m/s
c. 24.8 m/s

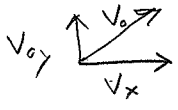
$v_x = \frac{d}{t} = \frac{30\ m}{1.7\ s} = 17.6\ m/s$

22. What is the speed of the ball just before it is caught? ← same as when released

a. 18.1 m/s
(b.) 19.5 m/s
c. 22.9 m/s

$v_y = v_{0y} - gt$

$v_y = 0$ at $t = 1.7/2 = 0.85\ s$

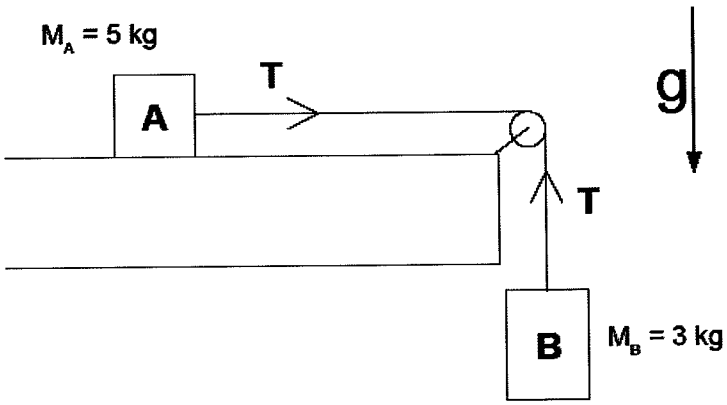


$v_{0y} = gt = 9.8\ m/s^2 \times 0.85\ s = 8.33\ m/s$

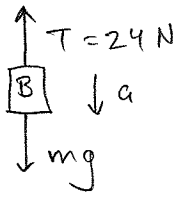
$v_0 = \sqrt{v_x^2 + v_{0y}^2} = \sqrt{(17.6\ m/s)^2 + (8.33\ m/s)^2} = 19.47\ m/s$

The following 2 questions concern the same physical situation:

A mass-less rope connects block A to block B across a frictionless pulley as shown in the figure. Block **A** slides across a horizontal surface with a coefficient of kinetic friction, μ_k. Block **B** hangs vertically downwards.
The mass of block **A** is 5 kg, and the mass of block **B** is 3 kg.
The tension, T, in the string is found to be 24 N

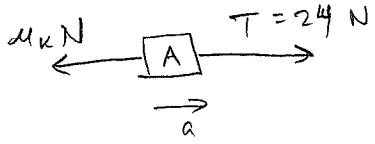


23. What is the acceleration of block B?
   a. 6.1 m/s^2
   b. 3.7 m/s^2
   (c.) 1.8m/s^2



$$T - m_B g = -m_B a \Rightarrow a = g - \frac{T}{m_B} = 9.8\ m/s^2 - \frac{24\ N}{3\ kg} = 1.8\ m/s^2$$

24. What is the value of μ_k, the coefficient of kinetic friction between block A and the surface?
   (a.) 0.3
   b. 0.2
   c. 0.1



$$T - \mu_k m_A g = m_A a$$

$$\mu_k = \frac{T}{m_A g} - \frac{a}{g}$$

$$= \frac{24\ N}{5\ kg\ 9.8\ m/s^2} - \frac{1.8\ m/s^2}{9.8\ m/s^2}$$

$$= 0.306$$