SDI LAB #7: NEWTON'S LAWS REVISITED

NAME ______________________________ _______________________ ______ ______ ______
Last (Print Clearly) First (Print Clearly) ID Number

LAB SECTION _______________________LAB TABLE POSITION___________________________

I. INTRODUCTION

This lab will enable you to review the essentials of Newton's three laws. Before you begin please review (a) the "Ground Rules for SDI Labs," Sec. I-C of SDI Lab #0.1; (b) operational definitions in SDI Lab #1, (c) Newtons laws in SDI #1, 2, 6 and in your textbook.

II. STATIONARY CART

Fig. 1 on the next page shows the present set up at your table. A low-friction cart is *at rest* on a *horizontal* runway. The cart is tied to a string which connects over a low-friction pulley to a weight W_2 which is suspended vertically above the floor. The cart is held stationary by a Disk of weight W_3. The weight W_2 (not shown to scale) is a 50 g disk holder with a 50 g mass on it so that $W_2 = m_2 g =$ $(0.10\ \text{kg})\ (10\ \text{m/s}^2) = 1.0\ \text{N}$.

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CART AT REST ON A HORIZONTAL RUNWAY

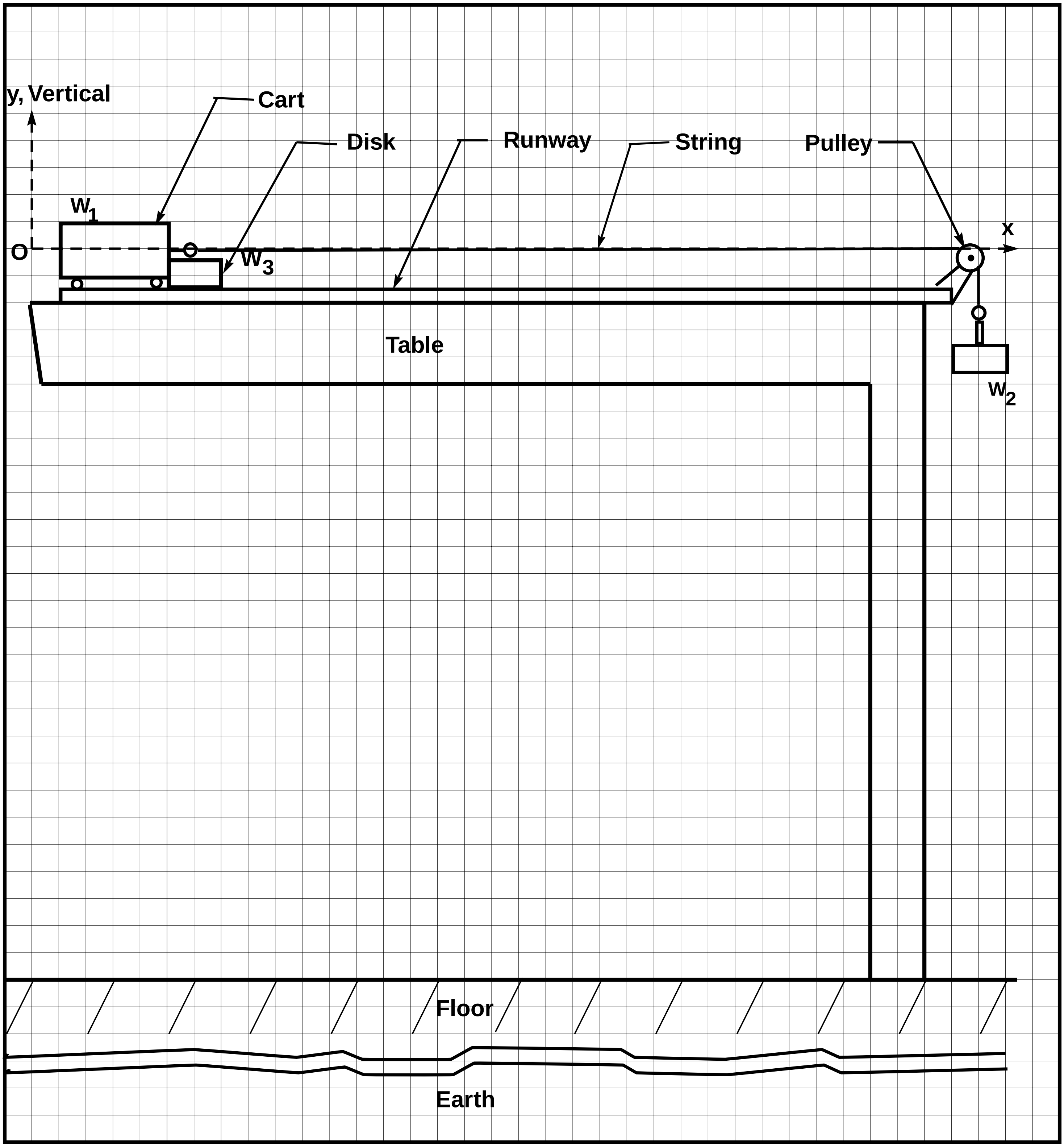

Fig. 1. A low-friction cart is connected by a string to a weight W_2 but is held stationary by a Disk. Assume that the mass of the string, the mass of the pulley, and the friction in the pulley are all negligible.

A. DEFINITION OF TERMS

1. In Fig. 1 the cart is at rest on a *horizontal* runway. Can you give a ***meaningful*** definition of the word "horizontal" ? {Y, N, U, NOT} ≡ {Yes, No, Uncertain, None Of These} (Here and throughout this lab, in accord with the SDI ground rules please **ENCIRCLE** a response and then **FULLY JUSTIFY** the response in the space below.)

2. Can you give a ***meaningful*** definition of the word "force"? {Y, N, U, NOT}

3. Can you give a ***meaningful*** definition of the term "*net* force"? {Y, N, U, NOT} (You need not redefine the word "force," just define the "net" in "net force.")

4. Can you give a ***meaningful*** definition of the term "instantaneous velocity"? {Y, N, U, NOT}

B. APPLICATION OF NEWTON'S LAWS

1. In Fig. 1, draw in ALL the forces acting **ON the CART**. Are the forces you have drawn in accord with Newton's First Law (N1)? {Y, N, U, NOT}

2. Are the forces that you have drawn in Fig. 1 in accord with Newton's Second Law (N2)? {Y, N, U, NOT}

3. In Fig. 1, show the Newton's Third Law (N3) reaction force to *each* force that you have drawn in "1" above. (Show the N3 reaction forces as properly labeled *dashed* red (if you are using the Giancoli color code) vector arrows


$\vec{\mathbf{F}}_{\text{on A by B}}$.)

4. What is the tension T in the string ***in terms of the mass*** $\boldsymbol{m_2}$ of the weight W_2? Please *justify* your answer.

5. Figure 2 shows an enlargement of the cart and the Disk of Fig 1. Can you show ALL the forces acting **ON the <u>DISK</u>**? {Y, N, U, NOT}

FORCES ON THE **DISK** OF FIGURE 1

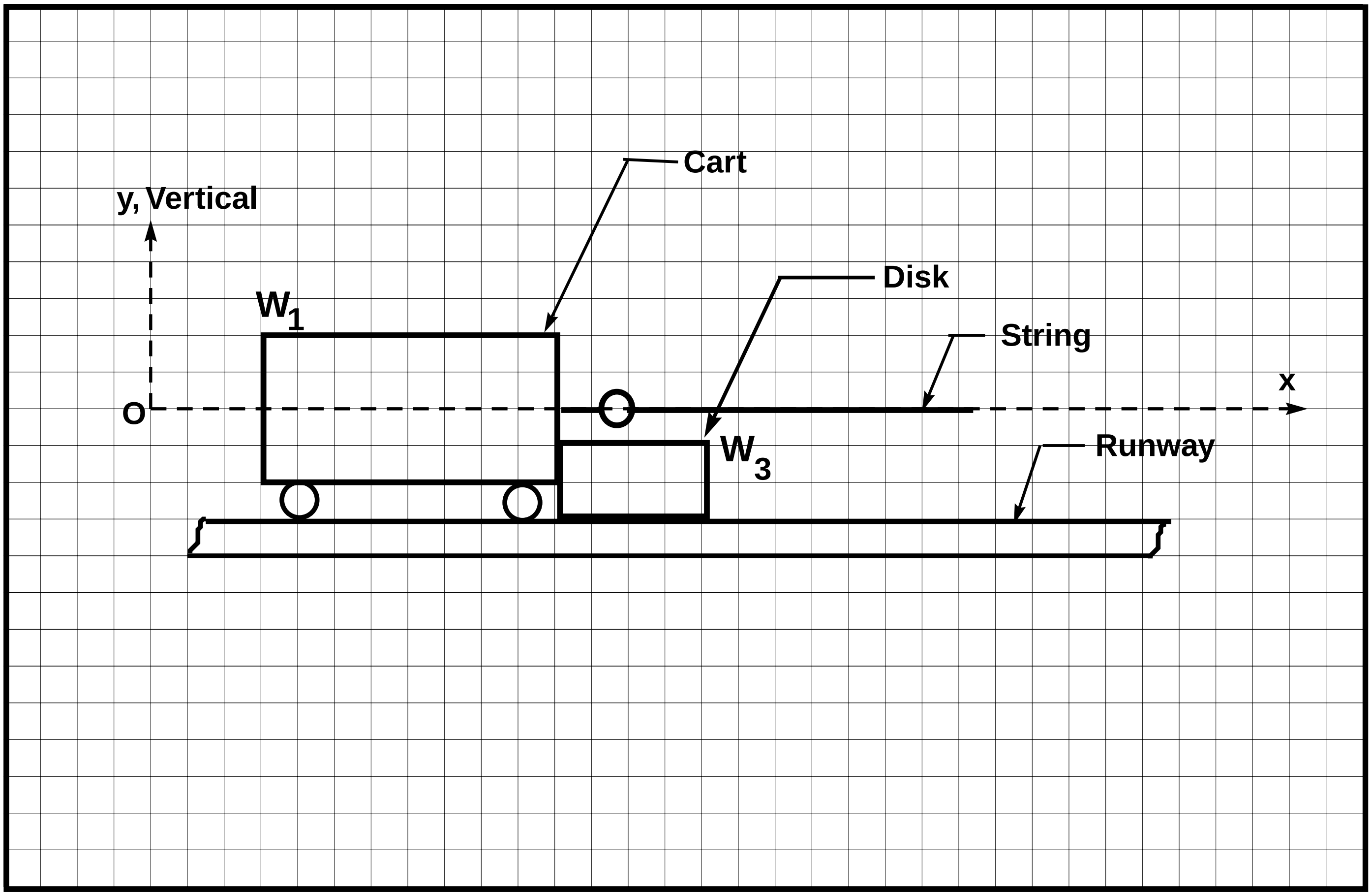

Fig. 2. An enlargement of the cart and the Disk of Fig. 1.

6. Are the forces you have drawn above in accord with Newton's First Law (N1)? {Y, N, U, NOT}

7. Can you indicate *in the drawing above* the values of **ALL** the forces ***in terms of the masses*** m_1, m_2, m_3, ***g, and the coefficient of static friction*** μ_s between the disk and the runway? {Y, N, U, NOT} (Here m_1 is the mass of the cart of weight W_1, of m_2 is the mass of the weight W_2, and m_3 is the mass of the disk of weight W_3.

III. CART IN MOTION

A. CART PULLED BY A STRING ATTACHED TO A WEIGHT W_2 = 1.0 N

1. Suppose you were to suddenly pull the Disk away from the cart so that the cart is free to move down the runway as shown in Fig. 3. The cart would then move with [(encircle one) decreasing, constant, increasing, none of these] speed down the runway. Please *justify* your answer.

2. Perform the experiment of "1" while carefully watching the motion of the cart. Are your observations in accord with your predictions? {Y, N, U, NOT}

3. Observe the motion in "2" during several trials. *Simultaneously* observe the motion of *both* the cart and the weight W_2 (the latter can be observed in the mirror against the wall). Fig. 3 shows "snapshot sketches" of the cart at three different instants of time: at *the instant the stop is removed*, near the middle of the runway, and near the end of the runway. In Fig. 3, show ALL the *force vectors* ***acting ON the CART*** at these 3 instants of time. Show the velocity and acceleration vectors of the cart if they exist.

CART PULLED BY A STRING ATTACHED TO A WEIGHT W_2 = 1.0 N

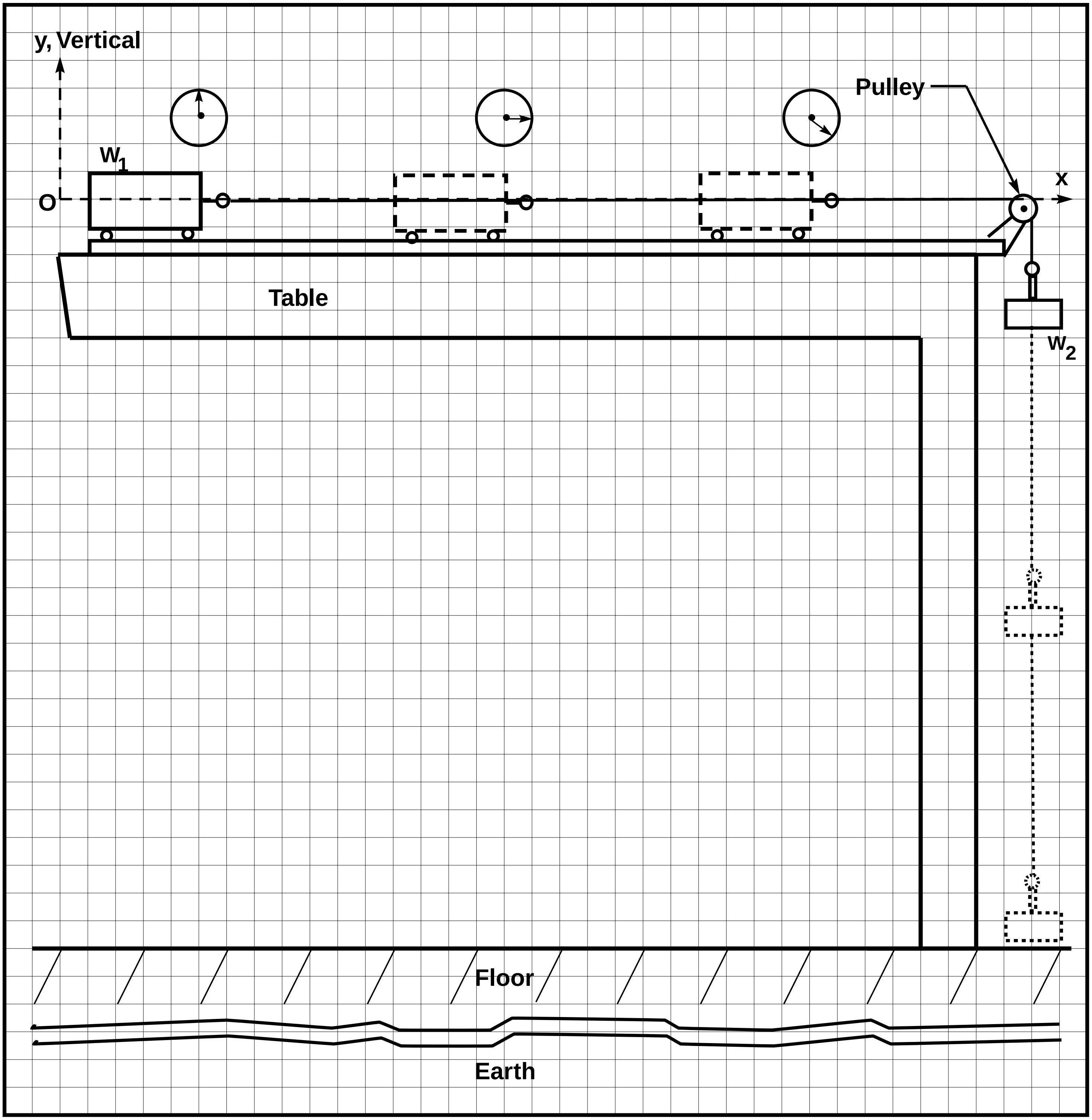

Fig. 3. Snapshot sketches of the motion of the cart pulled by a string attached to weight W_2 = 1.0 N. Assume as negligible (a) all frictional forces, (b) the mass of the pulley, (c) the mass and any stretching of the string.

4. The acceleration of the cart is [(encircle one) less than, the same as, greater than] the acceleration of the weight W_2. Please *justify* your answer.

5. In Fig. 3, considering only forces ON the cart, are there any forces in the y (vertical) -direction? {Y, N, U, NOT} If so, designate these forces in the space below in the form $\vec{\mathbf{F}}_{\text{on A by B}}$ where A and B are bodies.

6. Is there a *net* force on the cart in the y (vertical) -direction? {Y, N, U, NOT}

7. In Fig. 3, considering only forces ON the cart, are there any forces in the x (horizontal) -direction? {Y, N, U, NOT} If so, designate these forces in the space below in the form $\vec{\mathbf{F}}_{\text{on A by B}}$ where A and B are bodies.

8. Is there a *net* force on the cart in the x (horizontal) -direction? {Y, N, U, NOT}

9. Are your snapshot sketches in accord with N2? {Y, N, U, NOT}.

10. Do you know what the symbol "g" refers to when used in mechanics? {Y, N, U, NOT}

11. The acceleration of the cart is [(encircle one) less than, the same as, greater than] "g". Please *justify* your answer.

12. In Fig. 3, show the Newton's Third Law (N3) reaction force to *each* force that you have drawn on the cart *at the instant it is in the middle position*. (Show the N3 reaction forces as properly labeled *dashed* red vector arrows  $\vec{\mathbf{F}}_{\text{on A by B}}$.)

13. PLEASE OMIT THIS QUESTION FOR NOW, BUT RETURN TO IT AFTER COMPLETING THE REST OF THE LAB. Can you find the magnitude of the acceleration "a" of the cart in terms of the masses m_1 of the cart, m_2 of the weight W_2, and "g"? {Y, N, U, NOT} Please answer this question on the last page.

B. CART PULLED BY A STRING WHICH IS PULLED BY YOUR HAND.

1. Consider a *thought experiment* in which you pull on the string with a *constant* force $F_{\text{on string by hand}} = 1.0$ N in a direction vertically downward until your hand hits the floor, as shown in Fig. 4. The cart would then move with [(encircle one) decreasing, constant, increasing, none of these] speed down the runway. Please *justify* your answer. [You can get a "feel" for $F_{\text{on string by hand}} \approx 1.0$ N by pulling on the blue spring scale near the runway. (Of course, what you actually feel is $F_{\text{on hand by string}}$, the N3 reaction force to $F_{\text{on string by hand}}$.) Remember also that "quarter pounders" should be called "Newton-burgers," i.e., one Newton is the equivalent of about (1/4) pounds.]

CART PULLED BY A STRING TO WHICH YOUR HAND APPLIES A CONSTANT FORCE F = 1.0N.

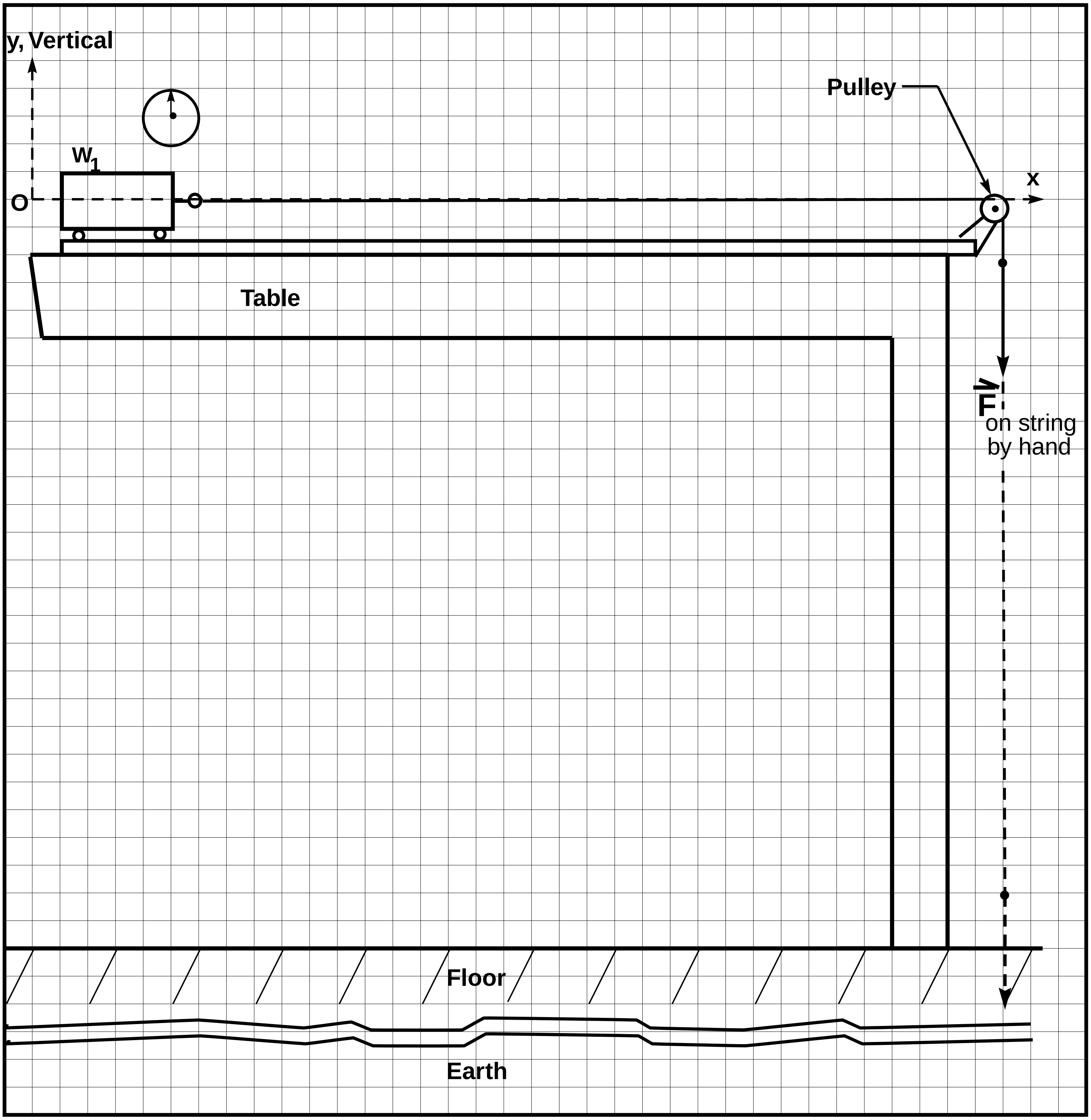

Fig. 4. A cart is pulled by a string on which your hand exerts a constant force $F_{\text{on string by hand}} = 1.0$ N vertically downward until your hand hits the floor. Assume as negligible (a) all frictional forces, (b) the mass of the pulley, (c) the mass and any stretching of the string.

1. The acceleration of the cart is [(encircle one) less than, about the same as, greater than] the cart of Fig. 3, which is attached by the string to the weight W_2 = 1.0 N. Justify your answer in terms of N2.

If you finish this section, please return to question 13 on p. 9 (repeated below for your convenience) but do your work in the space below.

13. Can you find the magnitude of the acceleration "a" of the cart of Fig. 3 in terms of the masses m_1 of the cart, m_2 of the weight W_2, and "g"? {Y, N, U, NOT}