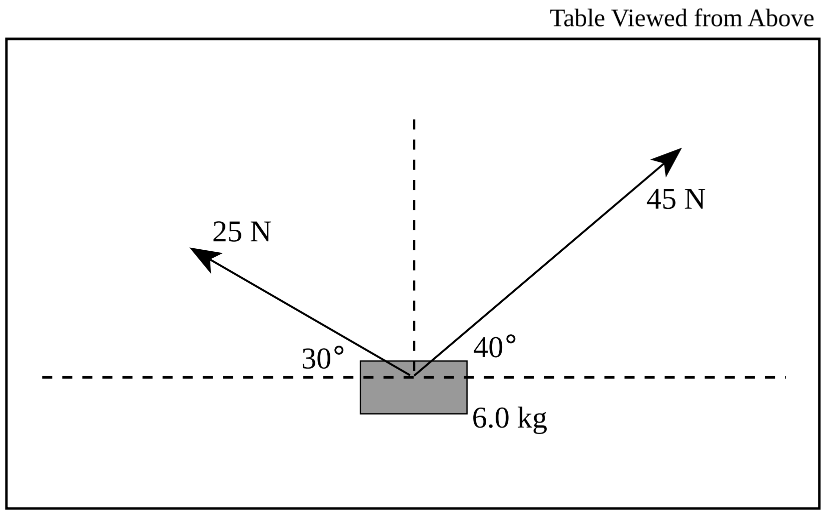
VECTOR DYNAMICS
PROVINCIAL EXAMINATION ASSIGNMENT
ANSWER KEY / SCORING GUIDE

PART A: Multiple Choice (each question worth ONE mark)

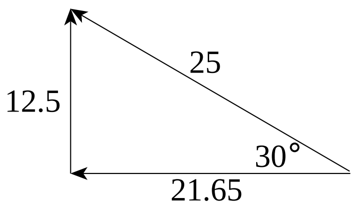
Q	**K**	**Q**	**K**
1.	D	27.	B
2.	B	28.	B
3.	D	29.	B
4.	A	30.	D
5.	D	31.	B
6.	D	32.	A
7.	C	33.	D
8.	A	34.	A
9.	C	35.	C
10.	A	36.	B
11.	A	37.	D
12.	C	38.	C
13.	B	39.	D
14.	B	40.	A
15.	D	41.	B
16.	C	42.	A
17.	B	43.	D
18.	B	44.	C
19.	D	45.	B
20.	C		
21.	B		
22.	C		
23.	A		
24.	D		
25.	A		
26.	B		

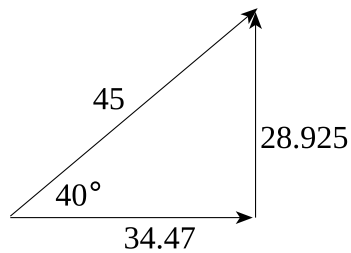
1. A 6.0 kg block is held at rest on a horizontal, frictionless air table. Two forces are pulling on this block in the directions shown in the diagram below.



What will be the magnitude of the acceleration on the 6.0 kg block at the moment it is released?

(7 marks)





Components:

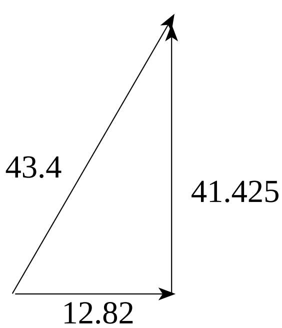
y direction

$F_y = (12.5 + 28.925) = 41.425 \text{ N}$ ← **1½ marks**

x direction

$F_x = 34.47 - 21.65 = 12.82 \text{ N}$ ← **1½ marks**

$F_{net} = 43.4 \text{ N}$ **2 marks**



Answer:

$$\left.\begin{aligned} a &= \frac{F_{net}}{m} \\ &= \frac{43.4 \text{ N}}{6.0 \text{ kg}} \\ &= 7.2 \text{ m/s}^2 \end{aligned}\right\} \textbf{2 marks}$$

SEE ALTERNATE SOLUTION OVER:

Alternate Solution:

If viewed as a 'hanging' mass, no penalty:

- this approach is more difficult

Then:

Components:

$F_x = 12.82\ \text{N}$ ← **1½ marks**

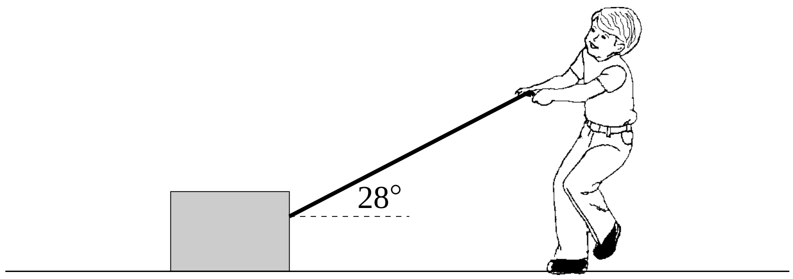
$F_y = 58.8 - 41.43 = 17.37\ \text{N down}$ ← **1½ marks**

$F_{net} = 21.6\ \text{N}$ **2 marks**

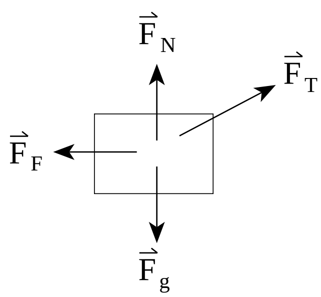
Answer:

$$\left.\begin{aligned} a &= \frac{F_{net}}{m} \\ &= \frac{21.6\ \text{N}}{6.0\ \text{kg}} \\ &= 3.60\ \text{m/s}^2 \end{aligned}\right\}$$ **2 marks**

2. A 60 kg block rests on the ground. A student exerts a 320 N force on the block by pulling on a rope, but friction prevents the block from moving.



a) Draw and label a free body diagram showing all forces acting on the block. **(2 marks)**



2 marks

b) Calculate the force of friction on the block. **(2 marks)**

$$F_F = F_T \cos 28°$$
$$= 283 \text{ N}$$

← **2 marks**

c) Calculate the normal force exerted by the ground on the block. **(2 marks)**

$$\begin{aligned} F_N &= F_g - F_T \sin 28^\circ \\ &= 588 - 150 \\ &= 438 \text{ N} \end{aligned}$$

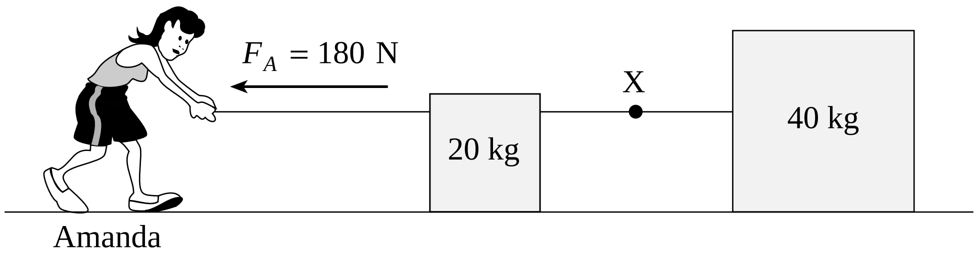
2 marks

d) Calculate the minimum coefficient of friction between the block and the ground. **(1 mark)**

$$\begin{aligned} F_F &= \mu F_N \\ \mu &= 0.65 \end{aligned}$$

1 mark

3. a) Amanda exerts a horizontal force of 180 N on a piece of rope causing two blocks of mass 20 kg and 40 kg to accelerate. Friction on the blocks is negligible. Find the tension force at **X** in the rope joining the two blocks together. **(5 marks)**



$F = ma$ (system as a whole) ← **1 mark**

$180 = (20 + 40)a$ ← **1 mark**

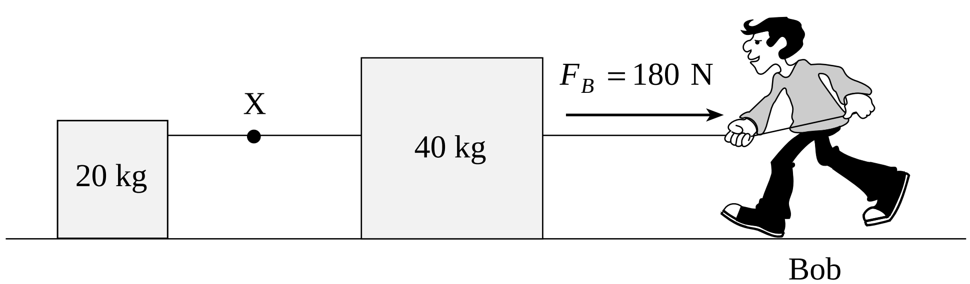
$\therefore a = 3.0 \text{ m/s}^2$ ← **1 mark**

$F = ma$ (40 kg mass only)

$F_T = 40(3.0)$ ← **1 mark**

$F_T = 120 \text{ N}$ ← **1 mark**

b) Bob exerts a force of equal magnitude in the opposite direction on an identical pair of blocks



How does the tension force at **X** compare to the value in part a)? (Circle one.) **(1 mark)**

i) The tension force is the same.

ii) The tension force is greater than in a).

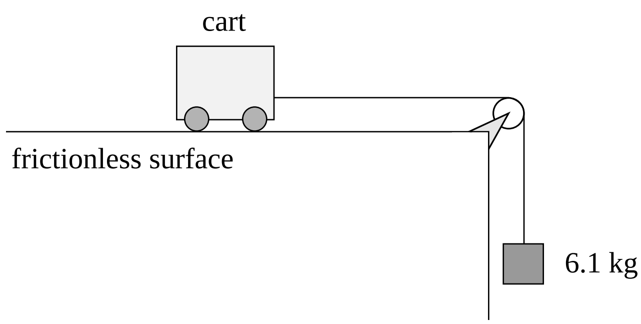
iii) The tension force is smaller than in a).

c) Using principles of physics, explain your answer to part b). **(3 marks)**

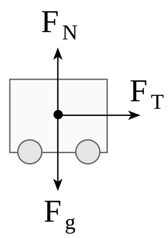
In both situations the **total mass** is the same so both **systems** accelerate at the same rate.

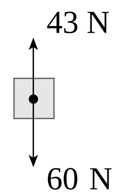
In b) the tension must accelerate a **smaller mass** at the **same rate** hence, from Newton's second law, $F = ma$, a smaller tension force will cause this.

4. In the diagram shown, the tension in the cord connecting the hanging mass and cart is 43 N.



a) Draw and label a free body diagram for the cart and the hanging mass. **(2 marks)**





← **2 marks for both**

b) Determine the mass of the cart. **(5 marks)**

$$a = \frac{F_{net}}{m} = \frac{60 - 43}{6.1} = 2.75 \text{ m/s}^2$$

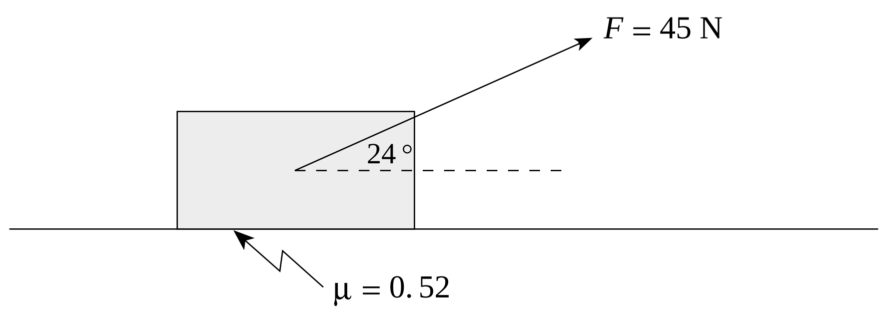
$$F_{net} = ma$$

$$F_T = ma$$

$$m = \frac{F_T}{a} = \frac{43}{2.75} = 16 \text{ kg}$$

← **5 marks**

5. A student drags a $7.0\ \text{kg}$ carton of apples across the floor by exerting a $45\ \text{N}$ force in the direction shown. The coefficient of friction between the carton and the floor is 0.52.



a) What is the magnitude of the normal force acting on the carton? **(2 marks)**

$F_N + F\sin 24° = F_g$ ← **1 mark**

$F_N + 18.3\ \text{N} = 68.6\ \text{N}$ ← **½ mark**

$F_N = 50.3\ \text{N}$ ← **½ mark**

b) What friction force acts on the carton? **(2 marks)**

$F_f = \mu F_N$ ← **1 mark**

$= 0.52(50.3)\ \text{N}$ ← **½ mark**

$= 26.2\ \text{N}$ ← **½ mark**

c) What is the acceleration of the carton? **(3 marks)**

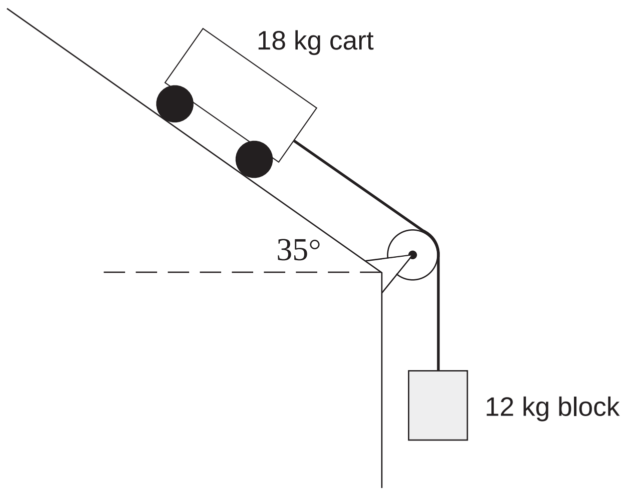
$F_{net} = ma$ ← **½ mark**

$F\cos 24° - F_f = ma$ ← **1 mark**

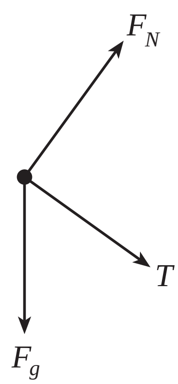
$41.1\ \text{N} - 26.2\ \text{N} = 7.0a$ ← **1 mark**

$a = 2.1\ \text{m/s}^2$ ← **½ mark**

6. An 18 kg cart is connected to a 12 kg hanging block as shown. (Ignore friction.)



a) Draw and label a free body diagram for the 18 kg cart. **(2 marks)**



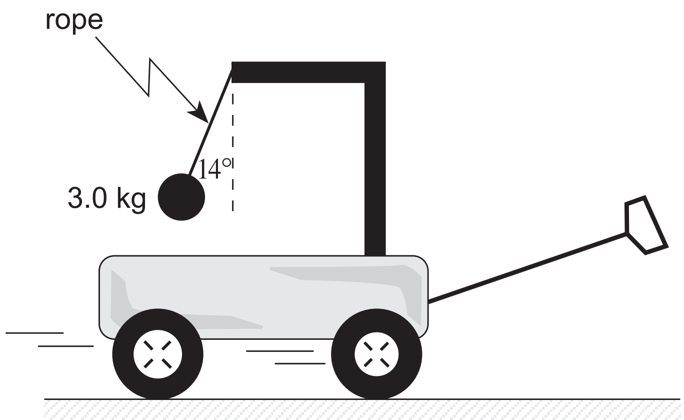
b) What is the magnitude of the acceleration of the cart? **(5 marks)**

$$\left.\begin{aligned} cart\ F_{//} &= mg\sin\theta \\ &= 18(9.8)\sin 35 \\ &= 101\text{ N} \end{aligned}\right\} \leftarrow \mathbf{1\tfrac{1}{2}\ marks}$$

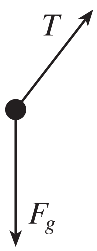
$$\left.\begin{aligned} W_{object} &= mg \\ &= 12(9.8) \\ &= 118\text{ N} \end{aligned}\right\} \leftarrow \mathbf{1\ mark}$$

$$\left.\begin{aligned} a_{system} &= \frac{F_{net}}{m} \\ &= \frac{W_1 + F_{//}}{m_1 + m_2} \\ &= \frac{118+101}{12+18} \\ a &= 7.3\text{ m/s}^2 \end{aligned}\right\} \leftarrow \mathbf{2\tfrac{1}{2}\ marks}$$

7. A 3.0 kg mass hangs at one end of a rope that is attached to a support on a child's wagon as shown in the diagram. The wagon is pulled to the right. (You may ignore air resistance.)

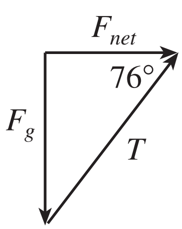


a) Draw and label a free body diagram showing the forces acting on the mass. **(2 marks)**



1 mark for each force ($\frac{1}{2}$ for labelling, $\frac{1}{2}$ for direction drawn correctly)

b) What is the acceleration of the wagon? **(3 marks)**



$$\tan 76° = \frac{F_g}{F_{net}}$$

$$F_{net} = \frac{F_g}{\tan 76°}$$

$$= \frac{3.0 \times 9.8}{\tan 76°}$$

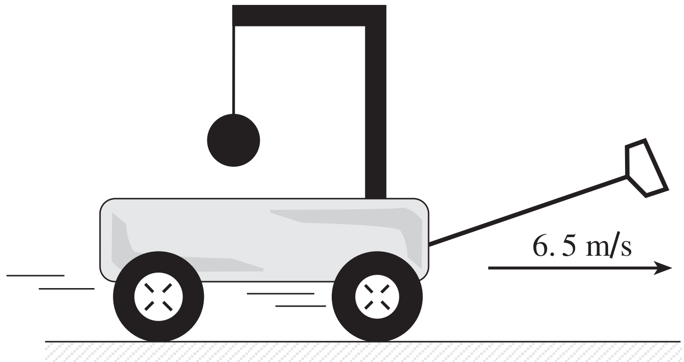
$$= 7.33 \text{ N}$$ ← **2 marks**

$$a = \frac{F_{net}}{m}$$

$$a = \frac{7.33}{3.0}$$

$$a = 2.4 \text{ m/s}^2$$ ← **1 mark**

c) On the diagram below, sketch the position of the mass when the cart reaches a constant velocity of 6.5 m/s. **(1 mark)**



d) Using principles of physics, explain why the mass will be in this position. **(3 marks)**

Constant velocity means acceleration = 0 (**1 mark**)

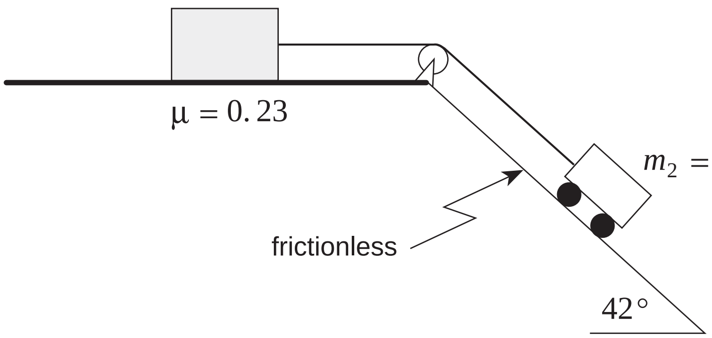
$\therefore F_{net} = 0$ (**1 mark**)

$\therefore$ Sum of all vertical forces is zero

$\therefore$ Tension $= F_g$ ($\frac{1}{2}$ **mark**)

$\therefore$ There is no horizontal force component, so the mass hangs straight down. ($\frac{1}{2}$ **mark**)

8. Two objects are connected as shown. The 12 kg cart is on a frictionless 42° incline while the 15 kg block is on a horizontal surface having a coefficient of friction $\mu = 0.23$.



Determine the acceleration of the system of masses. **(7 marks)**

$$F_f = \mu mg$$

$$= 0.23(15\text{ kg})9.8\text{ m/s}^2$$

$$F_f = 33.8\text{ N} \qquad \leftarrow \textbf{1 mark}$$

$$F_{||} = mg\sin\theta$$

$$= 12\text{ kg}\left(9.8\text{ m/s}^2\right)\sin 42°$$

$$F_{||} = 78.7\text{ N} \qquad \leftarrow \textbf{2 marks}$$

$$a_{system} = \frac{net\ F}{m}$$

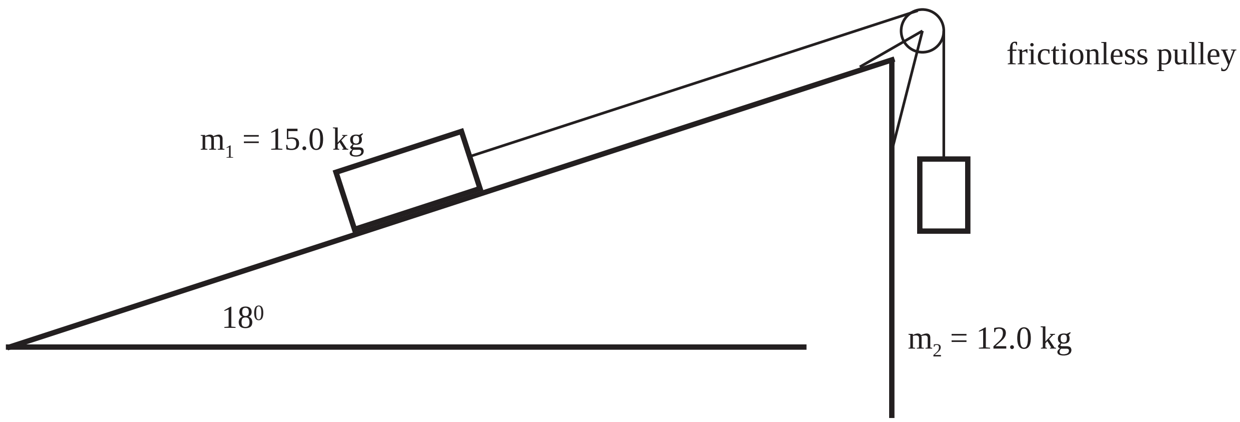
$$= \frac{F_{||} - F_f}{m_1 + m_2}$$

$$= \frac{78.7\text{ N} - 33.8\text{ N}}{12\text{ kg} + 15\text{ kg}} \qquad \leftarrow \textbf{4 marks}$$

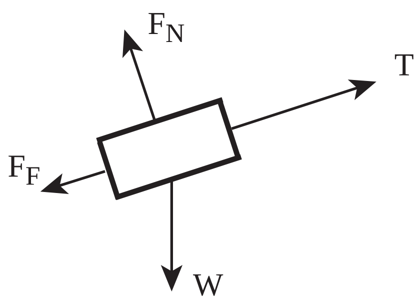
$$= 1.66\text{ m/s}^2$$

$$a = 1.7\text{ m/s}^2$$

9. As shown in the diagram below, a 15.0 kg block m_1 on an 18^0 inclined plane is connected by a light cord over a frictionless pulley to a hanging 12.0 kg block m_2. The 12.0 kg block accelerates down at 0.97 m/s^2.



a) Draw the free-body diagram for the 15.0 kg block and label all the forces on the diagram. (2 marks)



b) What is the coefficient of friction between the block and the inclined plane? (7 marks)

$W_2 = m_2 g$

$= (12.0)(9.8)$ 0.5 mark

$= 117.6\text{N}$

F_g on 15.0kg block

$F_g = W_1 \sin \quad = m_1 g \sin$

1 mark

$= (15.0)(9.8)(\sin 18)$

$= 45.4\text{N}$

$F_{NET} = (m_1 + m_2)a$

$= (15.0 + 12.0)(0.97)$ 1 mark

$= 26.2\text{N}$

$F_{NET} = W_2 \quad F_g \quad F_F$

$F_F = W_2 \quad F_g \quad F_{NET}$

1 mark

$F_F = 117.6\text{N} \quad 45.4\text{N} \quad 26.2\text{N}$

$F_F = 46\text{N}$

$F_F = \quad F_N \}$ 0.5 mark

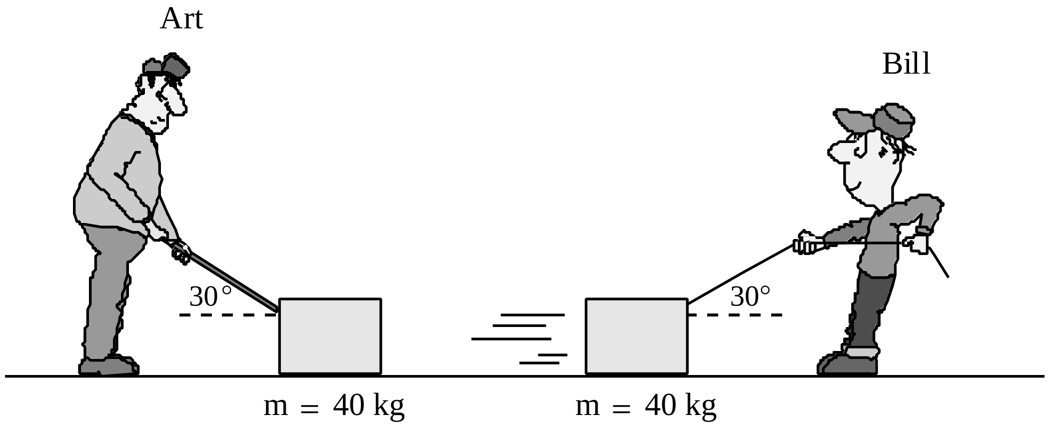
$F_N = W_1 \cos \quad = m_1 g \cos$

$= (15.0)(9.8)(\cos 18)$ 1 mark

$= 140\text{N}$

$= \frac{F_F}{F_N} = \frac{46\text{N}}{140\text{N}} = 0.33$ 2 marks

10. Art and Bill both attempt to move identical 40 kg crates across identical rough surfaces. Art exerts an 80 N force by pushing with a stick. Bill exerts an 80 N force by pulling on a cord. Bill's crate slides across the ground, but Art's will not move.



Explain this observation, using principles of physics. **(4 marks)**

When Art exerts a force on the crate there is a downward component which must be opposed; there is therefore a large normal reaction force.

When Bill exerts a force there is an upward component which means the normal reaction force will be small.

As the force of friction depends on the normal reaction force $(F_F = \mu F_N)$, Art encounters a large friction force and he is unable to move the crate.

Bill, however, is able to move his crate because the friction force is small.

11. A classmate insists a book cannot be held against a wall by pushing horizontally as shown in Diagram A. He insists that there must be a vertical force component, provided by pushing against the book from below, as shown in Diagram B.

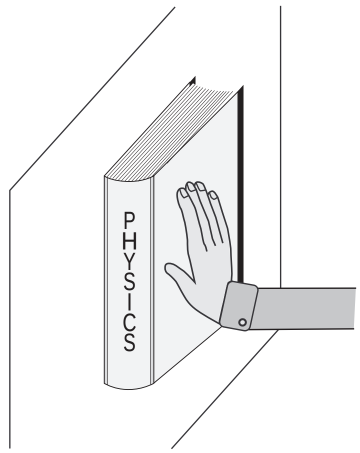


Diagram A

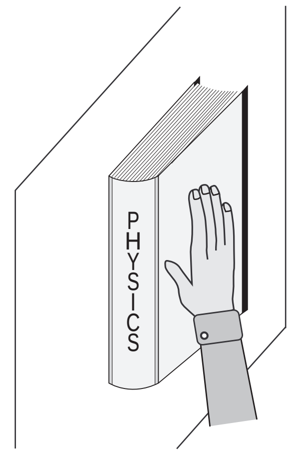


Diagram B

Using principles of physics, show that the situation in Diagram A is reasonable. **(4 marks)**

A normal force opposite to the applied force exists. i.e., Newton's third law. ← 1 mark

Some friction force $\left(F_f\right)$ exists. ← 1 mark

The friction force depends on the normal force. ← 1 mark

With a sufficiently large enough applied force the friction force can oppose the force of gravity. ← 1 mark