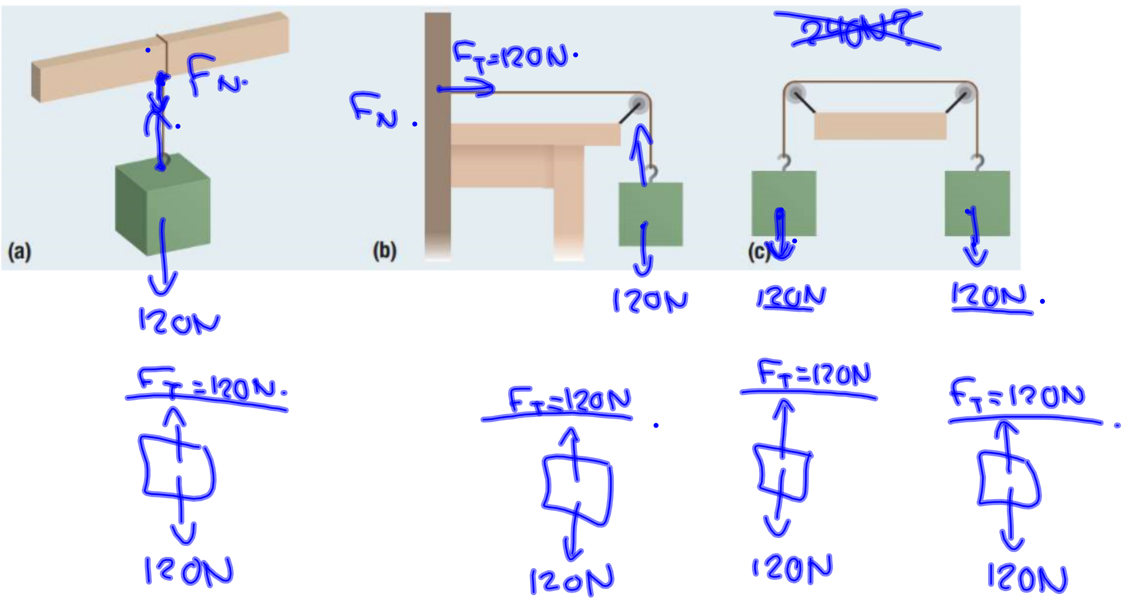
3.5 Using Newton's Laws

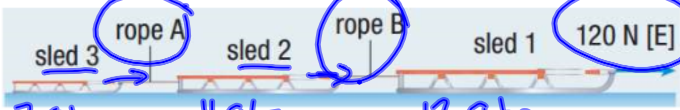
1. Tension and Newton's laws

Tension:	A pulling force exerted by ropes and strings. Always pulls toward the centre. $\vec{F}_{T1} = -\vec{F}_{T2}$
Newton's third law	$\vec{F}_A = -\vec{F}_R$
ignoring tension	Sometimes we can pretend that 2 or more objects are 1 combined object, and then ignore tension.

Each object below has a force of gravity of 120 N [down] acting on it. Determine the tension in each string.



Three sleds are tied together and pulled east across an icy surface with an applied force of 120 ~~12~~ N [E]. The mass of sled 1 is 12.0 kg, the mass of sled 2 is 11.0 kg, and the mass of sled 3 is 7.0 kg. Assume there is no friction.



7.0kg. 11.0kg 12.0kg.

a. Determine the acceleration of the sleds.

Combined sleds.

F_N, F_g, 120N.

$m = 12 + 11 + 7$
$= 30\,kg$.

$F_{Net} = ma$.
$120N = 30a$.
$a = \frac{120}{30} = 4.0\,m/s^2$.

b. Calculate the magnitude of the tension in rope A.

Sled 3: $F_{Net} = ma$.
$F_{TA} = 7a = 7(4)$

$F_{TA} = 28N$.

c. Calculate the magnitude of the tension in rope B.

Sleds 2+3:

F_N, F_g, F_{TB}

$m = 7 + 11$
$= 18\,kg$

$F_{Net} = ma$
$F_{TB} = 18(4)$
$= 72N$.

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② Sled 1:

F_{TB}, 120N.
$m = 12\,kg$
$a = 4$.

$F_{Net} = 120N - F_{TB}$.
$= ma$.

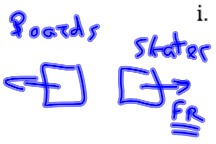
2. Kinematics and Newton's laws

Kinematics equations:	Assume constant acceleration. When a is changing, break the problem into steps.

Starting from rest, an ice skater (54.0 kg) pushes the boards with a force of 130.0 N [W] 1 and moves 0.704 m. He then moves at a constant velocity 2 for 4.00 s before he digs in his skates and starts to slow down. When he digs in his skates, he causes a net force of 38.0 N [W] to slow him down until he stops. 3.

a. Determine the acceleration of the skater

i. when he is pushing on the boards



1

$F_{net}=ma$.

$130N[E]=(54)a$

$a=\frac{130}{54}=2.407 m/s^2$.

ii. just after he stops pushing on the boards

2

No accel. $a=0 m/s^2$.

iii. when he starts to slow down

3.

$F_{net}=ma$.

$38.0N[W]=54a$

$a=\frac{54}{38}=0.704 m/s^2 [W]$.

b. How far does he move?

1 $\Delta d=0.704m$, $v_f=?$, $a=2.407 m/s^2$, $v_i=0 m/s$.

$v_f^2=v_i^2+2a\Delta d$ $\quad v_f=\sqrt{v_i^2+2a\Delta d}=\sqrt{0+2(2.407)(0.704)}$

$=1.841 m/s$.

2 $\Delta t=4.0s$, $v=1.841 m/s$. $\quad \Delta d=v\Delta t=(1.841)(4)=7.364m$.

3 $v_i=1.841 m/s$, $v_f=0 m/s$, $a=-0.704 m/s^2$, $\Delta d=?$

$v_f^2=v_i^2+2a\Delta d$ $\quad \Delta d=\frac{v_f^2-v_i^2}{2a}=\frac{0-1.841^2}{2(-0.704)}=1.981m$.

Total: $\Delta d=0.704m+7.364+1.981=10.1m$.

Homework: page 147: #1-2, 4-6