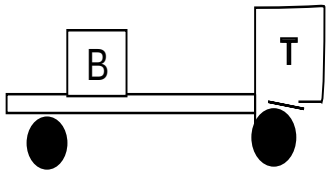
THE OLD BOX AND TRUCKBED PROBLEM

CONCEPT LIST
Static Friction
Kinetic Friction
Acceleration
Relative Acceleration
Frames of Reference
Noninertial Frames
Law of Inertia
Newton's 2nd Law
Normal Forces
Coefficients of Friction



ex/ m_B = 4kg and μ_S = .5 and μ_K = .3
(1) Assume that a_{TE} = 4 m/s^2 , find a_{BE} = ?
(2) What is the maximum acceleration of the truck without the box slipping?
(3) Assume that a_{TE} = 7 m/s^2 ,
- (a) find a_{BE} = ?
- (b) does the box move left or right?
- (c) find a_{BT} = ?
- (d) is the kinetic friction force left or right?
- (e) according to a person on the truck, what force accelerates the box toward the back of the truck?
- (f) does the law of inertia hold in the truck's frame of reference?

Solutions:
(1) Since the acceleration of the truck is less than 5 m/s^2 , the box does not slip and hence $\mathbf{a_{BE} = 4\ m/s^2}$ and keeps up with the truck.
(2) The maximum acceleration of the box without slipping is determined by the maxF_S=μ_S•N = .5(40) = 20N (since the normal force = F_g = mg =4(10), using 10m/s^2 for g). Now using F_{NET} = ma or 20=4a_{BE} we get $\mathbf{a_{BE} = 5\ m/s^2}$.
(3a) Since the truck accelerates at greater than 5 m/s^2, the box slips and the friction force that acts on it is a kinetic friction force. F_K=μ_K•N =.3(40) = 12N.
Now using F_{NET} = ma or 12=4a_{BE} we get $\mathbf{a_{BE} = 3\ m/s^2}$.
(3b) Both! With respect to the truck's frame of reference the box moves to the left or negative-x direction, but to a person standing on the earth, the box moves right or in the positive-x direction with an accelertion of 3 m/s^2 .
(3c) $a_{BT} = a_{BE} + a_{ET}$ = (3) + (-7) = –4 m/s^2 . (Notice that $a_{ET} = -a_{TE}$.)
(3d) In either reference frame, the kinetic friction force opposes the relative velocity of the box with respect to the surface of the truckbed, **right!**
(3e) The friction force would tend to keep the box from slipping back off the truckbed, yet the acceleration of the box with respect to the truck is –4 m/s^2.
To be consistent with Newton's 2nd Law, a person <u>on the truck</u> would have to make-up a force which pushed it off to the left!
(3f) The law of inertia also has problems in an accelerated or noninertial frame of reference. The box doesn't stay at rest and even moves left or backwards on the truck! And the only unbalanced force is a friction force to the right or forward?