ISP209 Exam 2A **Calculator and Pencil only** Name:______________________
October 15, 2003 **No books or notes** ID: ______________________

Hooke's law: $F=kx$; Weight on Earth: $W = F_G = mg$, $g = 9.81\text{N/kg}$

Newton's 1st and 2nd laws for the effects of forces acting on a mass:

1st law: Balanced forces acting on a mass *do not* change its speed or direction.

2nd law: Unbalanced forces acting on a mass *continuously* change its speed or direction.

1. In which of the following circumstances, are balanced forces acting the object?

a) Forces acting on a person bouncing on a trampoline when reaching the lowest point.
At lowest point unbalanced force causes person to begin to move upward.

b) Forces on the moon going around the earth at a constant speed. (direction changes!)
An unbalanced force (earth – moon gravity) causes moon to circle the earth.

c) Forces on a bicyclist coasting (not pedaling) with decreasing speed on a flat road.
An unbalanced force (air friction) causes bicyclist to slow down.

d) Forces on a ball thrown straight upward at its highest point.
At highest point unbalanced force (gravity) causes ball to begin to move downward.

e) None of the above

2. Which statement below is true:

a) An action – reaction pair of forces can *never* be a balanced pair of forces.
(each force acts on a separate object) (balanced forces must act on same object)

b) The tension forces generated at the ends of an ideal spring are balanced.
(NO, its an action – reaction pair.)

c) A person hanging from a chinning bar has only gravity affecting the body.
(NO, bent bar pulls up on the hands of the person.)

d) When standing on the ground I feel the force gravity alone.
(NO, ground pushes up on the feet of the person.)

e) none of the above

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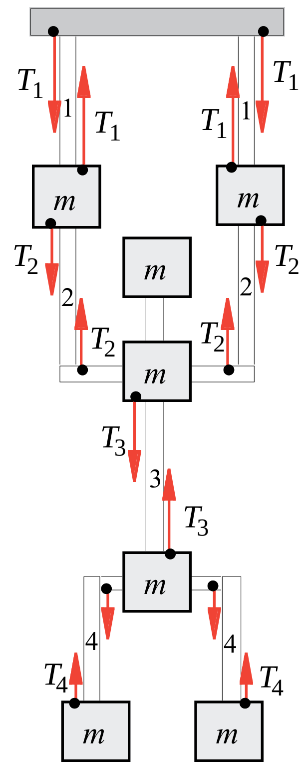


Shown hanging limply downward from a bar, Mr. Lego, consists of seven body parts, each with a mass, *m*, connected by a massless skeleton with numbered vertical bones.

To help you answer the question, **draw** the tension vectors (arbitrary length) acting at each end of the bones 1-4 and label them, T_1 to T_4, respectively.

3. What are the magnitudes of these three bone tensions?

	T_1	T_2	T_3
a)	3.5 *mg*	2.5 *mg*	3.0 *mg*
b)	7.0 *mg*	2.5 *mg*	3.0 *mg*
c)	3.5 *mg*	3.0 *mg*	1.0 *mg*
d)	2.0 *mg*	2.0 *mg*	3.0 *mg*
e)	7.0 *mg*	5.0 *mg*	3.0 *mg*

(each) T_4 balances weight of 1 mass, $T_4 = mg$
T_3 balances forces which sum to weight of 3 masses, $T_3 = 3mg$.
$2T_2$ balances forces which sum to weight of 5 masses, $2T_2 = 5mg$, $T_2 = 2.5\ mg$
$2T_1$ balances forces which sum to weight of 7 masses, $2T_1 = 7mg$, $T_1 = 3.5\ mg$

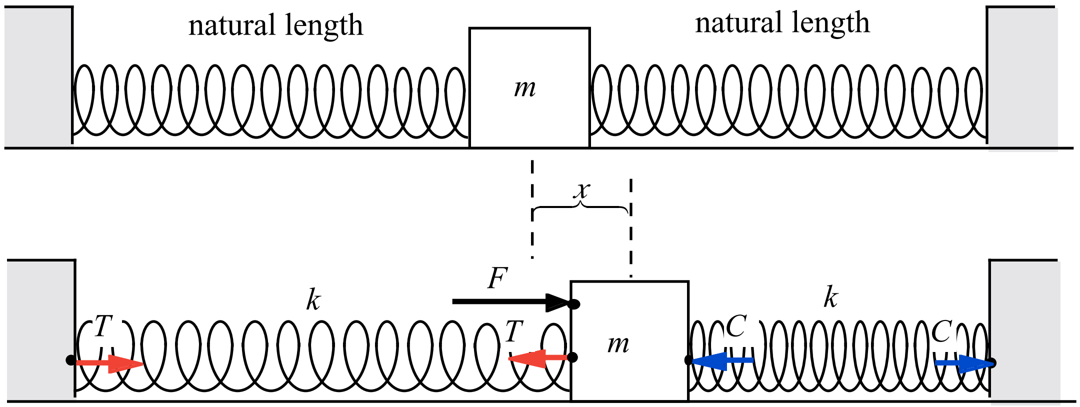
4. When a 20 kg mass is hung from a spring it stretches 0.04 m What is the spring constant of the spring? (Hint: use both force relationships at the top of this page.)

a) 5 N/cm   b) 5000 N/m   c) 250 N/m   d) 80 N/m   e) 0.2 N/m

$$F = kx,\ F_G = mg$$

$$F = F_G;\quad kx = mg;\ k = \frac{mg}{x} = \frac{(20\text{ kg})(10\text{ N/kg})}{.04\text{ m}} = \underline{5000\text{ N/m}}$$

Hooke's law: $F=kx$; Weight on Earth: $W = F_G = mg$, $g = 9.81$N/kg



frictionless

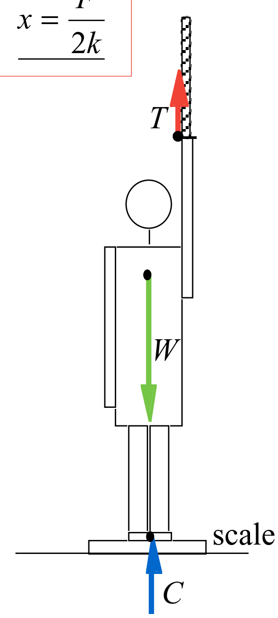
5. Two natural length springs, spring constant k, are attached to a mass and to walls on either side. Applied slowly, a force, F, stretches the spring on the left, and compresses the spring on the right, leaving the mass stationary at a new position. Draw the springs force vectors acting on the mass to determine the distance, x, the mass has moved.

a) $x = \dfrac{k}{2F}$ b) $x = \dfrac{2F}{k}$ c) $x = \sqrt{\dfrac{2F}{k}}$ d) $x = \dfrac{2k}{F}$ e) $x = \dfrac{F}{2k}$

Applied force, F, balanced by left spring tension, T, plus right spring compression, C.

$T = kx, \quad C = kx$

$F = T + C = 2kx; \quad x = \dfrac{F}{2k}$



6. Shown at the right are two of the forces *acting on* a person with a weight, W = 700 N, pulling *down* on a rope with a force of 200 N, to generate a rope tension, T. Also acting on the person is the compression force, C, generated by the spring in the scale. Draw this compession force vector and determine its magnitude. (balance forces)

a) C = 900 N
b) C = 700 N
c) C = 500 N
d) C = zero
e) C = 1100 N

$$\mathbf{T} + \mathbf{W} + \mathbf{C} = 0$$
$$(+T) + (-W) + (+C) = 0$$
$$C = W - T = (700 - 200)\text{ N} = \underline{500\text{ N}}$$

7. On a planet where g_p= 2.5 N/kg , the weight of an object is 1000 N. On the Earth, what is the **weight** of the object (use g = 10 N/kg)?

a) 4000 N b) 400 N c) 2500 N d) 10 N e) 250 N

$$m = \frac{W_p}{g_p} = \frac{1000\text{ N}}{2.5\text{ N/kg}} = 400\text{ kg}; \quad W = mg = (400\text{ kg})(10\text{ N/kg}) = \underline{4000\text{ N}}$$

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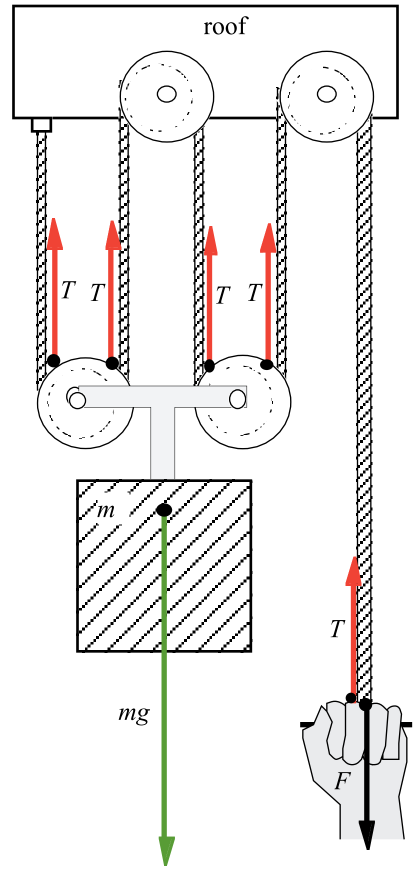


8. A rope (ideal spring) passes through two pulleys attached to the roof and two pulleys attached to a mass m (pulleys & bracket are massless), as shown in the figure above. To hold the mass stationary, a person standing on the ground must have what minimum weight?

a) mg

b) $4mg$

c) $\dfrac{mg}{4}$

d) $4m$

e) any weight will do.

$T = F$ (action - reaction pair)

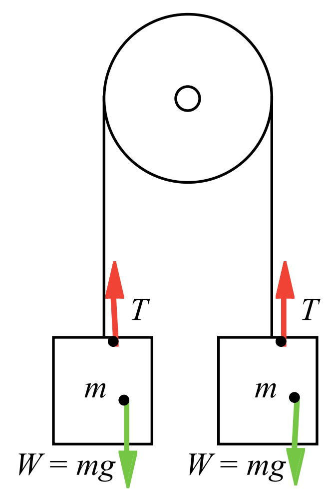
$4T = mg$ (balance force on mass)

$T = \dfrac{mg}{4}$ (weight of person must be this big)

9. For the same apparatus as in the previous problem, if a person can apply a maximum force, F, on the rope as shown, what mass, m, can be held stationary?

a) $\dfrac{F}{g}$ b) $\dfrac{4F}{g}$ c) $\dfrac{F}{4g}$ d) $4gF$ e) $\dfrac{F}{2g}$

$T = F = \dfrac{mg}{4}$; $m = \dfrac{4F}{g}$



10. A mass, m, is attached to each side of a string hanging over a (frictionless and massless) pulley, as shown on the right. What tension force acts on each mass?

a) mg b) $2mg$ c) $\dfrac{mg}{2}$ d) $\dfrac{mg}{4}$ e) $\dfrac{3mg}{2}$

$T = W = mg$ (balance forces on EACH mass)