Review 2

Problem-Solving Tactics

(HR&W, Chapters **5-6** + 1,2,3,and 4)

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Newton's Laws

I. If no net force acts on a body, then the body's velocity cannot change.

II. The net force on a body is equal to the product of the body's mass and acceleration.

III. When two bodies interact, the force on the bodies from each other are always equal in magnitude and opposite in direction ($\mathbf{F}_{12} = -\mathbf{F}_{21}$)

Force is a vector
Force has direction and magnitude
Mass connects Force and acceleration;

$$\vec{F}_{tot} = 0 \Leftrightarrow \vec{a} = 0 \text{ (constant velocity)}$$

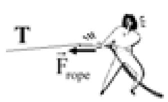
$$\vec{F}_{tot} = m\vec{a} \text{ for any object}$$

$$F_{tot,x} = ma_x \qquad F_{tot,y} = ma_y \qquad F_{tot,z} = ma_z$$

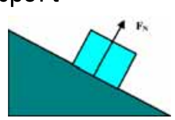
Forces:

- Gravitational Force: $\vec{F}_g = m\vec{g}$ down to the ground

- Tension Force: $\vec{T}$ along the string



- Normal Force: $\vec{N}$ perpendicular to the support



- Friction Force
  - Static; maximum value $\mathbf{f}_s = \mu_{st}\mathbf{N}$
  opposite to the component of other forces parallel to the support
  - Kinetic; value $\mathbf{f}_k = \mu_{kin}\mathbf{N}$
  opposite to the **velocity**, parallel to the support

$\mu_{st} > \mu_{kin}$

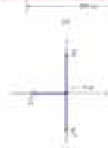


TABLE 2-1 Equations for Motion with Constant Acceleration[a]

Equation Number	Equation	Missing Quantity
2-11	$v = v_0 + at$	$x - x_0$
2-15	$x - x_0 = v_0 t + \frac{1}{2}at^2$	v
2-16	$v^2 = v_0^2 + 2a(x - x_0)$	t
2-17	$x - x_0 = \frac{1}{2}(v_0 + v)t$	a
2-18	$x - x_0 = vt - \frac{1}{2}at^2$	v_0

[a] Make sure that the acceleration is indeed constant before using the equations in this table.

Problem 1: Please mark the version of the exam you are taking

A) YOU ARE TAKING VERSION A
B)
C)
D)
E)

Problem 2: Find the mass of an object whose initial speed of 4 m/s is reduced to zero with a constant 4 N force in 2 seconds.

B) 0.5 kg
B) 2 kg
C) 4 kg
D) 8 kg
E) 16 kg

$F = ma$; $a = \frac{F}{m}$; $m = \frac{F}{a}$

$v = v_0 - a \cdot t \Rightarrow v_0 = a \cdot t \Rightarrow$

$a = v_0 / t$

$m = \frac{F}{v_0} \cdot t = \frac{4N}{4 m/s} \cdot 2s = \boxed{2 kg}$

Problem 3: Two forces acting on an object of mass 5.0 kg give rise to an acceleration **a** = (2.0 m/s²)**i** + (3.0 m/s²)**j**. One of the forces is $\mathbf{F_1}$ = (10 N)**i** – (4 N)**j**. The other must be

A) $\mathbf{F_2}$ = (10 N)**i** + (15 N)**j**
B) $\mathbf{F_2}$ = (20 N)**i** + (11 N)**j**
C) $\mathbf{F_2}$ = (10 N)**i**
D) $\mathbf{F_2}$ = (12 N)**i** – (1 N)**j**
E) $\mathbf{F_2}$ = (19 N)**j**

$m = 5 kg$ $\vec{a} = 2\hat{i} + 3\hat{j}$ (m/s^2)

$\vec{F_1} = 10\hat{i} - 4\hat{j}$ (N)

$\vec{F_2} = ?$ $\vec{F}_{net} = \vec{F_1} + \vec{F_2} \Rightarrow \vec{F_2} = \vec{F}_{net} - \vec{F_1}$

$\vec{F}_{net} = m \cdot \vec{a} = 10\hat{i} + 15\hat{j}$ (N)

$\vec{F_2} = 10\hat{i} + 15\hat{j} - (10\hat{i} - 4\hat{j}) = \boxed{19\hat{j} \ (N)}$

Problem 4: A 5 kg lamp is suspended by a string from the ceiling inside an elevator moving up with decreasing speed. If the magnitude of the elevator's acceleration is 3 m/s², what is the tension in the string?

A) 64 N
B) 49 N
C) 34 N
D) 15 N
E) 60 N

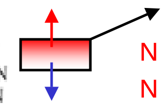
$\downarrow \vec{a}$ $\uparrow T$ $\downarrow mg$ x

$mg - T = ma$

$T = mg - ma = m(g - a)$

$T = 5kg (9.8 - 3) m/s^2 = 5 \cdot 6.8 = \boxed{34 N}$

Problem 5: A 10 kg block is dragged along a horizontal frictionless surface with a 100 N force that makes an angle of 25° with the horizontal. The normal force exerted by the surface on the block is



A) 98 N
B) 140 N
C) 7.4 N
D) 56 N
E) 2 N

N + F sin θ = mg;
N = - F sin θ + mg
N = -100 sin 25° + 10*9.8 (Newton) = 56 N

Problem 6: A block initially moving at 4 m/s upwards on an incline comes to rest after traveling 5 m up the incline. What is the angle between the incline and the horizontal in degrees?

A) 9.4
B) 81
C) 45
D) 53
E) 6.7

$v^2 - v_o^2 = -2ax$; ➔ $a = v_o^2 / 2x$

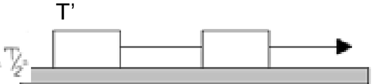
$F = mg \sin\theta$; ➔ $a = g \sin\theta$ ➔ $\sin\theta = v_o^2 / (2gx)$;

$\theta = \sin^{-1}(v_o^2 / (2gx)) = \sin^{-1}(0.16) = 9.4^o$

Problem 7: The tension in the string on the right of the right block is 36 N. Each block has a mass of 2 kg. The surface is frictionless. What is the tension in the string between the blocks?

A) 9 N
B) 36 N
C) 18 N
D) 12 N
E) 27 N

T'



$m_1 + m_2 = M$; $Ma = T \Rightarrow a = \frac{T}{m_1 + m_2}$

$T - T' = m_1 a$; $T' = T - m_1 a = T(1 - \frac{m_1}{m_1 + m_2}) = T/2$

T' = 18 N

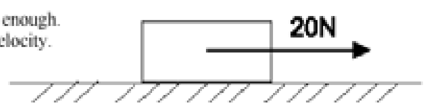
Problem 8: A 2000kg car slides on the ice and stops in 20m due to the frictional force between the car and the ice. If the initial speed of the car is 5 m/s, the coefficient of kinetic friction between the ice and car is:

A) 0.
B) 0.064
C) 0.013
D) 1.0
E) 9.8

$v^2 - v_o^2 = -2ax$; ➔ $a = v_o^2 / 2x$
$F = mg\mu$; ➔ $a = g\mu$ ➔ $\mu = v_o^2 / (2gx)$;
$\mu = 25 / (19.6 \cdot 20)) = 0.064$ (mass is not important !)

Problem 9: A block of mass 5kg is pulled along a horizontal floor by a force of 20N as shown in the figure. The coefficient of static friction is 0.4. The coefficient of dynamic friction is 0.2. the magnitude of the acceleration of the block is

A) The block does not accelerate. The 20N force is not strong enough.
B) The acceleration is zero, but the block moves at constant velocity.
C) 2.04 m/s²
D) 0.24 m/s²
E) 9.8 m/s²

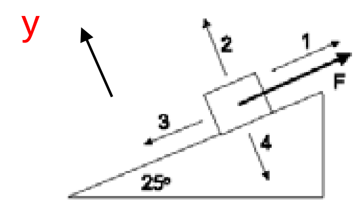


$F > F_{st}$ (20N > 19.6N) or $F \cong F_{st}$ (20N ≅ 19.6N)
$a = (F - F_{kin})/m = (20-9.8)/5 = 2.04$ m/s² (too many sign. Figs.)

Problem 10: As shown in the Figure below, a sled is pulled up a snow covered hill by a force F. The angle of the slope is 25 degrees. The weight of the sled is 100N. Which of the labeled arrows below indicate the DIRECTION of the frictional force?

A) Arrow 1
B) Arrow 2
C) Arrow 3
D) Arrow 4
E) None of the above

ma = F - mg sin θ - f
ma = F – 42N – f
f is directed as "3"



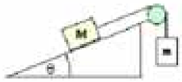
Problem 11: Referring to the sled problem above, the coefficient of static friction is 0.25 and the coefficient of kinetic friction is 0.15. What value of F is required such that the sled moves at a constant velocity?

A) 56 N
B) 65 N
C) 42 N
D) 91 N
E) 100 N

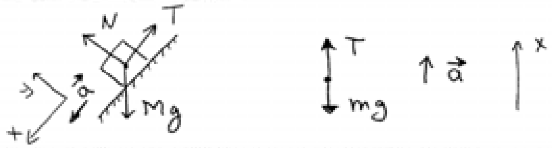
Y: $mg\cos\theta = N$; $f = \mu N$; ➔ $f = \mu mg \cos\theta$
$ma = 0 = F - mg\sin\theta - \mu mg\cos\theta$
$F = mg(\sin\theta + \mu\cos\theta)$
F = 100(N)*(sin 25° + 0.15 cos 25°)= 55.8 (N) ≈ 56 (N)

WORKOUT PROBLEM I: [1 point for each part]

For the diagram shown, assume that the pulley is massless and frictionless, the incline is frictionless, the string is massless, M = 4.0 kg and θ = 43°. Starting from rest, the mass M moves downhill with a speed that is increasing at a rate of 2.0 m/s^2.



a) Draw the free-body-diagram of each of the objects.



b) Write components of Newton's 2nd Law of Motion for each of the masses using symbols only (M, m, θ, g etc.)

$\boxed{M}$

x: $Ma = Mg\sin\theta - T$ *

y: $\emptyset = N - Mg\cos\theta$

$\boxed{m}$

$ma = T - mg$

c) Solve the equations in part b using the data supplied and find the tension in the string T and the mass m

* $T = M(g\sin\theta - a)$

$T = 4(9.8 \cdot \sin 43° - 2) =$

$= 18.7\ N$

$m(a+g) = T$

$m = \frac{T}{a+g}$

$m = \frac{M(g\sin\theta - a)}{a+g}$

$m = \frac{4(9.8\sin 43 - 2)}{2 + 9.8}$

$m = 1.6\ kg$

d) What value of m would have given an uphill motion of M with constant speed ?

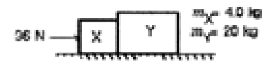
$a = 0$

$T = m'g$

$T = M\cdot(g\sin\theta)$

$m' = \frac{T}{g} = M\cdot\sin\theta = 4\cdot\sin 42°\ [kg] = 2.7kg$

9. Two blocks (X and Y) are in contact on a horizontal frictionless surface. A 36-N constant force is applied to X as shown. The magnitude of the force exerted by Y on X is:



A) 1.5 N
B) 6.0 N
C) 29 N
D) 30 N
E) 36 N

$a = \frac{F}{m_x + M_y} = \frac{36N}{20kg + 4kg}$

$= \frac{36}{24} = 1.5\ \frac{m}{s^2}$

IInd Newton's law for the Block X:

$a_x = \frac{36N - F_y}{m_x} = 1.5\ m/s^2$; $F_y = 36N - 4kg \cdot 1.5\ \frac{m}{s^2} = 30N$

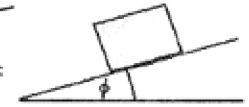
11. A block is at rest on a horizontal plank of wood. The plank is slowly lifted at one end while the other end stays on the floor. If the coefficient of static friction between the block and the plank is 0.5, what is the steepest angle the plank can have before the block begins to slide without being pushed?

A) 27°
B) 37°
C) 45°
D) 53°
E) 59°

$\mu_{st}^{max} = \tan\theta$

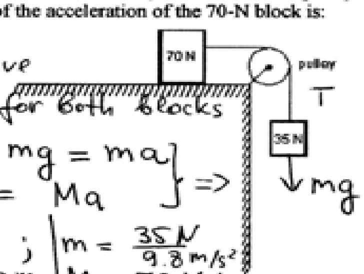
$\theta = \tan^{-1} 0.5 =$

$= 26.5°$



13. Two blocks with the weights of 70-N and 35-N are connected by a string as shown. If the pulley is massless and the surface is frictionless, the magnitude of the acceleration of the 70-N block is:

A) 1.6 m/s^2
B) 3.3 m/s^2
C) 4.9 m/s^2
D) 6.7 m/s^2
E) 9.8 m/s^2



Acceleration should have the same magnitude for both blocks

for 35N block: $-T + mg = ma$

for 70N block: $T = Ma$ }⇒

⇒ $Ma + ma = mg$; $m = \frac{35N}{9.8\ m/s^2}$

$a = \frac{m}{M+m}\cdot g = 3.3\ \frac{m}{s^2}$; $M = 70\ N/9.8\ m/s^2$

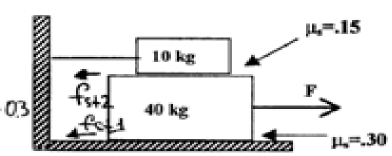
14. A horizontal force F is gradually increased until the 40 kg block begins moving to the right. The 10 kg block cannot move because of the cord attaching it to the wall at left. For what force F does the lower block just start to move?

A) 14.7 N.
B) 117.6 N
C) 132.3 N.
D) 147 N.
E) 161.7 N.

$F \geq f_{st1} + f_{st2}$

$f_{st1} = (10kg + 40kg)\cdot g \cdot 0.3$

$f_{st2} = 10kg \cdot g \cdot 0.15$



$F \geq 50kg \cdot 9.8\frac{m}{s^2} \cdot 0.3 + 10kg\ 9.8\ m/s^2 \cdot 0.15 = 161.7\ N$