Physics 1303(001),1403(801) **Professor Scalise**
Spring 1996 **Midterm #2**

Name: ________________ ID number:________________

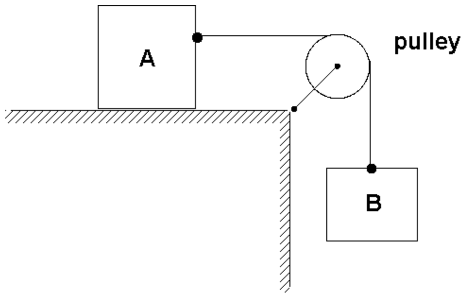
This exam is worth 100 points. It consists of 13 multiple-choice questions worth 6 points each and a partial credit section worth a maximum of 22 points.

Don't get hung up on the questions. They should only take a few minutes each. If you find yourself spending more than a few minutes on a question you are probably looking at it the wrong way. You should skip it temporarily and return to it later.

NOTE - The equation sheets are on the last pages. If you think that it makes referring to them easier, you can remove them from the rest of the exam.

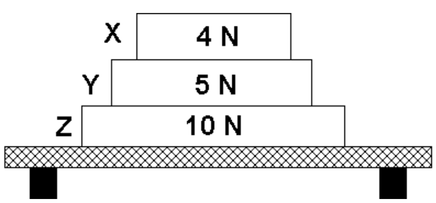
<u>GOOD LUCK</u>

1. Block A has a mass of 6 kg and block B has a mass of 2 kg. The surface and pulley are frictionless. What is the magnitude of the acceleration of block A?



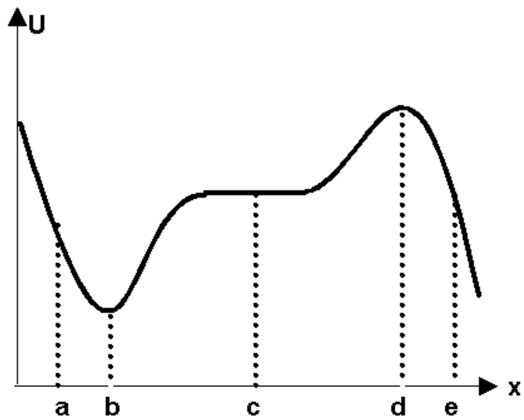
   (a) 2.5 m/s^2
   (b) 4.9 m/s^2
   (c) 0 m/s^2
   (d) 7.4 m/s^2
   (e) 9.8 m/s^2

2. Three books (X, Y, and Z) rest on a table. The weight of each book is indicated. The **net** force acting on book Y is:



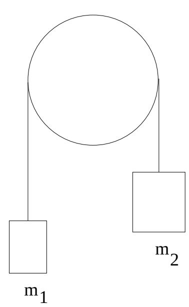
   (a) 5 N up
   (b) 9 N down
   (c) zero
   (d) 4 N down
   (e) none of these

3. The diagram shows a plot of the potential energy as a function of x for a particle moving along the x axis. The points of **unstable** equilibrium are:



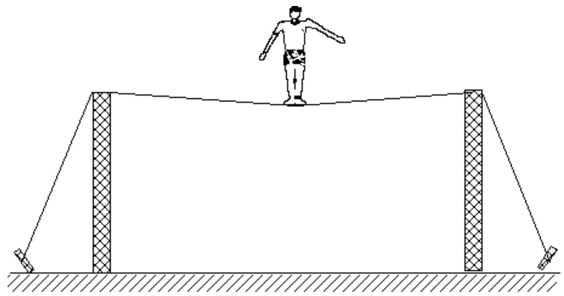
(a) only d
(b) only a, c, d, and e
(c) only c and d
(d) only a, d, and e
(e) only a and e

4. Consider the following Atwood's machine. The system accelerates from rest. What is the tension in the string if $m_1 = 4$ kg and $m_2 = 8$ kg?



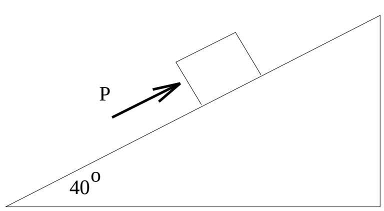
(a) 39 N
(b) 0 N
(c) 78 N
(d) 52 N
(e) 118 N

5. A circus performer of weight W is walking along a “high wire” as shown. The wire is almost horizontal and is deflected only slightly by the performer. The tension in the wire is:



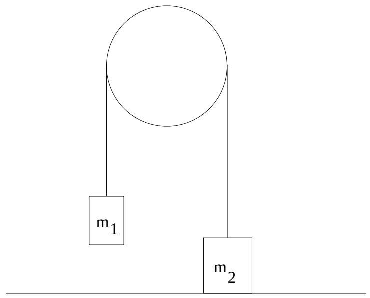
(a) independent of W
(b) much more than W
(c) approximately W
(d) much less than W/2
(e) approximately W/2

6. A block of mass 3 kg is pushed up rough slope inclined at an angle of 40° from the horizontal. The coefficient of kinetic friction is 0.2 and the applied force P has a magnitude of 30 N and is directed along the slope. What is the magnitude of the normal force?



(a) 42 N
(b) 23 N
(c) 19 N
(d) 35 N
(e) 3.2 N

7. If $m_1 = 2$ kg and $m_2 = 10$ kg, what is the force of the table on the mass m_2?



(a) 92 N
(b) 78 N
(c) 98 N
(d) 20 N
(e) 6.5 N

8. A 5 kg brick is dropped from rest from the top of a 90 m building. Neglecting air resistance, what is the speed of the brick just before it hits the ground?

(a) 30 m/s
(b) 42 m/s
(c) 66 m/s
(d) 94 m/s
(e) none of these

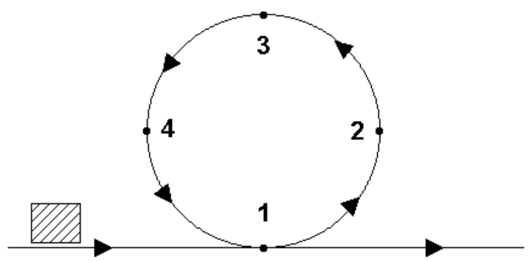
9. A 0.5 kg mass is whirled in a vertical circle of radius 1.5 m. The speed of the mass when it is at "12 o'clock" is 5.0 m/s. What is the speed of the mass when it is at "3 o'clock"?

   (a) 6.3 m/s
   (b) 5.2 m/s
   (c) 5.0 m/s
   (d) 7.4 m/s
   (e) 4.5 m/s

10. How much work is done by a spring of spring constant 8 N/m as it is moved from position 1 where it is stretched 6 m from equilibrium to position 2 where it is stretched only 3 m from equilibrium?

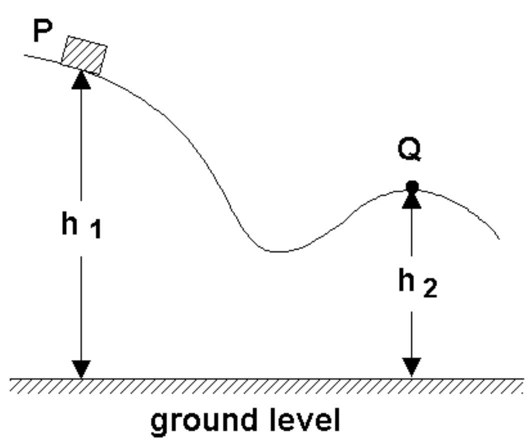
    (a) +108 J
    (b) -108 J
    (c) +36 J
    (d) -36 J
    (e) none of these

11. A rectangular block is moving along a frictionless path when it encounters the circular loop as shown. The block passes points 1,2,3,4,1 before returning to the horizontal track. At point 3:



(a) its mechanical energy is a minimum
(b) the forces on it are balanced
(c) it is not accelerated
(d) it experiences a net upward force
(e) its speed is a minimum

12. The block has a speed of 4 m/s at point P and travels along the frictionless track shown. If $h_1 = 15$ m and $h_2 = 10$ m then at point Q, its speed will be

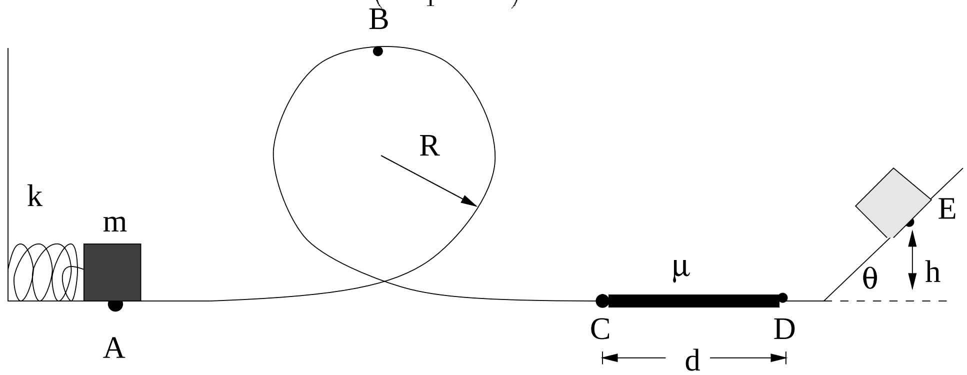


(a) 9.9 m/s
(b) 13.9 m/s
(c) 9.1 m/s
(d) 10.7 m/s
(e) need to know the mass

13. Which of the following five quantities is NOT an expression for energy? Here m is a mass, g is the acceleration due to gravity, h, x, and d are distances, F is a force, v is a speed, a is an acceleration, and k is a spring constant.

   (a) $\frac{1}{2}mv^2$
   (b) mgh
   (c) $\frac{1}{2}kx^2$
   (d) ma
   (e) Fd

Partial Credit Section (22 points)



A block of mass m=0.4 kg initially compresses a spring of spring constant k=10000 N/m a distance x=0.1 m. The block is released from rest at point A and slides over a smooth surface fashioned into a circular loop of radius R=1.5 m. The surface is rough only between points C and D, where μ_k=0.3 for a distance of d=2.5 m. Then the block climbs a smooth slope inclined at an angle θ=20° to the horizontal and comes to a stop at a height h above the horizontal.

It would be prudent to use variables as much as possible and only substitute numbers in at the very end of each part.

What is the speed of the block at point B, V_B? (4 points)

What is the force of the track on the block at point B? (4 points)

What is the speed of the block at point C, V_C? (3 points)

What is the speed of the block at point D, V_D? (3 points)

What is the force of the slope on the block at point E? (3 points)

In words, what is the action-reaction partner to the force of the slope on the block at point E? (2 points)

How high does the block rise, h, before coming to rest at point E? (3 points)

USEFUL FORMULÆ AND CONSTANTS

Average velocity and acceleration

$$\bar{\vec{v}} = \frac{\Delta \vec{r}}{\Delta t} \qquad \bar{\vec{a}} = \frac{\Delta \vec{v}}{\Delta t}$$

Instantaneous velocity and acceleration

$$\vec{v} = \frac{d\vec{r}}{dt} \qquad \vec{a} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{r}}{dt^2}$$

Equations for motion with a constant acceleration

$$\vec{v}(t) = \vec{v}_0 + \vec{a}t$$

$$\vec{r}(t) - \vec{r}_0 = \vec{v}_0 t + \tfrac{1}{2}\vec{a}t^2$$

$$\vec{r}(t) - \vec{r}_0 = \tfrac{1}{2}[\vec{v}_0 + \vec{v}(t)]t$$

$$[\vec{v}(t)]^2 = \vec{v}_0^{\,2} + 2\vec{a}\cdot[\vec{r}(t) - \vec{r}_0]$$

Relative Velocity

$$\vec{v}_{ac} = \vec{v}_{ab} + \vec{v}_{bc} \qquad \vec{v}_{ab} = -\vec{v}_{ba}$$

Radial Acceleration

$$a_r = \frac{v^2}{r}$$

Tangential Acceleration

$$a_t = \frac{d|\vec{v}|}{dt} = \frac{d}{dt}(\text{speed})$$

Newton's Second Law $\vec{F} = m\vec{a}$

Derivative and integrals of power functions

$$\frac{d}{dx}(Ax^n) = nAx^{n-1} \qquad \int Bx^n\,dx = \frac{B}{n+1}x^{n+1} + constant$$

Quadratic equation

$$ax^2 + bx + c = 0 \implies x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Weight $W = mg$

Friction $f_k = \mu_k N$ $\qquad f_s \le \mu_s N$

Newton's Third Law $\vec{F}_{12} = -\vec{F}_{21}$

Centripetal Force $\sum F_r = ma_r = m\frac{v^2}{r}$

The Work-Energy Theorem

$$W = \int_{\vec{r}_i}^{\vec{r}_f} \vec{F} \cdot \vec{ds} \qquad\qquad K = \frac{1}{2}m(\vec{v}\,)^2$$

$$W_{\text{net}} = K_f - K_i = \Delta K$$

Potential Energy (for Conservative Forces)

$$\Delta U = U_f - U_i = -\int_{\vec{r}_i}^{\vec{r}_f} \vec{F} \cdot d\vec{r} = -W_{\text{cons}}$$

$$F_x = -\frac{dU}{dx}$$

Some Common Forces and Their Potential Energies

Gravity	$F = -mg$	$U = mgh$
Spring	$F = -kx$	$U = \frac{1}{2}kx^2$

Conservation of Mechanical Energy

$$E = K + U$$

$\Delta E = E_f - E_i = W_{\text{nc}} =$ **Work done by non-conservative forces**

$$W_{\text{nc}} = \Delta K + \Delta U$$

Dot Product

$$\vec{A} \cdot \vec{B} = A_xB_x + A_yB_y + A_zB_z = |\vec{A}||\vec{B}|\cos\theta$$

Instantaneous Power

$$P = \vec{F} \cdot \vec{v}$$

Average Power

$$P_{\text{avg}} = \frac{W}{\Delta t}$$

Physical Constants

Acceleration due to gravity (g)	9.80 m/s^2 = 32 ft/s^2
Average earth-moon distance	3.84×10^8 m
Average earth-sun distance	1.49×10^{11} m
Average radius of the earth	6.37×10^6 m
Mass of the earth	5.98×10^{24} kg
Mass of the moon	7.36×10^{22} kg
Mass of the sun	1.99×10^{30} kg
Gravitational constant (G)	6.672×10^{-11} $N \cdot m^2/kg^2$

Conversion Constants

Length

1 in. = 2.54 cm
1 m = 39.37 in. = 3.281 ft
1 ft = 0.3048 m
12 in. = 1 ft
3 ft = 1 yd
1 yd = 0.9144 m
1 km = 0.621 mi
1 mi = 1.609 km
1 Å= 10^{-10} m
1 mm = 10^{-3} m
1 μm = 10^{-6} m = 10^4 Å
1 lightyear = 9.461×10^{15} m

Force

1 N = 10^5 dyne = 0.2248 lb
1 lb = 4.448 N
1 dyne = 10^{-5} N = 2.248×10^{-6} lb

Velocity

1 mi/h = 1.47 ft/s = 0.447 m/s
1 mi/h = 1.61 km/h
1 m/s = 100 cm/s = 3.281 ft/s
1 mi/min = 60 mi/h = 88 ft/s

Mass

1000 kg = 1 t (metric ton)
1000 g = 1 kg
1 slug = 14.59 kg
1 u = 1.66×10^{-27} kg

Acceleration

1 m/s^2 = 3.28 ft/s^2 = 100 cm/s^2
1 ft/s^2 = 0.3048 m/s^2 = 30.48 cm/s^2

Energy

1 J = 0.738 ft·lb = 10^7 erg
1 cal = 4.186 J
1 Btu = 252 cal = 1.054×10^3 J
1 eV = 1.6×10^{-19} J
931.5 MeV = 1 u
1 kW·h = 3.6×10^6 J

Power

1 hp = 550 ft·lb/s = 0.746kW
1 W = 1 J/s = 0.738 ft·lb/s
1 Btu/h = 0.293 W

Improper Conversions

1 lb (weight) = 0.454 kg (mass) at the surface of the earth