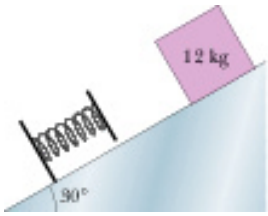
Sample Physics 135-1 Placement Exam

A. Multiple Choice Questions:

1. An airplane pilot sets a compass course due west and maintains an airspeed of 210 km/h. After flying for 20 minutes, the plane is over a town 50 km west and 10 km south of the starting point. In what direction is the wind blowing?

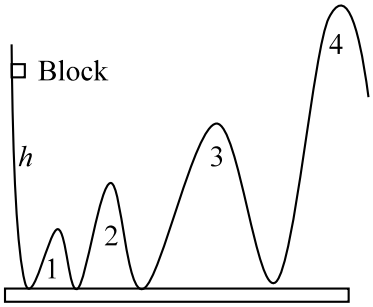
a. directly south (north to south)
b. directly north
c. directly east
d. directly west
e. toward the southwest
f. toward the southeast
g. toward the northeast
h. toward the northwest
i. not enough information to answer

2. A block is released from rest on a frictionless incline. Below the block is a spring. The block momentarily stops for an instant when it has compressed the spring by some maximum amount. Where on its way down the slope does the block's speed reach its maximum value?



a. before the block reaches the spring
b. when the block reaches the spring (at the instant of contact)
c. sometime after the block starts to compress the spring but before the spring reaches maximum compression

3. In the figure at right, a small initially stationary block is released on a frictionless ramp at a height of *h*. The hills have identical circular tops but different heights, and the valleys have identical circular bottoms but the same height (zero). (Assume that the block does not fly off any hill.) Rank the normal force on the block on hill 1, hill 2, hill 3, and in the valley between hill 3 and hill 4 (call it valley 34).

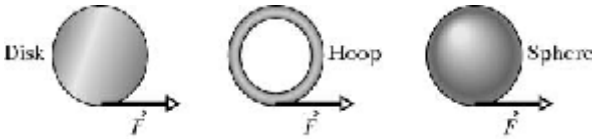


a. valley 34 > hill 3 > hill 2 > hill 1
b. hill 3 > hill 2 > hill 1 > valley 34
c. valley 34 < hill 3 < hill 2 < hill 1
d. valley 34 = hill 3 = hill 2 = hill 1
e. none of the above

4. A dog stands on a flatboat that is floating in calm water some distance from shore. The dog walks a few feet on the boat toward the shore and then halts. What happens to the boat while the dog is walking? Assume that there is no friction between the flatboat and the water.

a. The flatboat stays where it is with respect to the shore.
b. The flatboat shifts toward the shore.
c. The flatboat shifts away from the shore.
d. The direction of the flatboat's shift depends on the speed of the dog relative to the boat.

5. In the figure, a cylindrical disk, a hoop, and a solid sphere are made to spin about fixed central axes (like a top) by means of strings wrapped around them, with the strings producing the same constant tangential force on all three objects. The three objects have the same mass and radius, and they are initially stationary. Rank the objects according to their angular speed, greatest first, when the strings have been pulled for a certain time *t*.



a. Disk > Hoop > Sphere
b. Disk > Sphere > Hoop
c. Hoop > Sphere > Disk
d. Hoop > Disk > Sphere
e. Sphere > Disk > Hoop
f. Sphere > Hoop > Disk

6. A ball is rolling along at constant speed v without slipping on a horizontal surface when it comes to a hill that rises at a constant angle above the horizontal. In which case will the ball go higher up the hill: if the hill has enough friction to prevent slipping or if the hill is perfectly smooth (frictionless)?

a. when the hill has friction
b. when the hill is smooth
c. ball goes to same height whether there is friction or not

7. A spacecraft is enroute from Earth to the Moon, moving along a line that runs from the center of the Earth to the center of the Moon. Neglecting the gravity due to the Sun, the other planets, and the other stars in the Galaxy, the point where the gravitational force on the spacecraft is zero is:

a. halfway between the Earth & the Moon.
b. closer to Earth than to the Moon.
c. closer to the Moon than to the Earth.
d. nowhere - because gravity never totally vanishes except at an infinite distance.

B. Free Response Questions

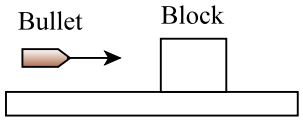
1. A rocket is fired vertically from rest at the surface of the Earth and ascends with a constant vertical acceleration of 8.0 m/s^2 for 8.33 minutes. Its fuel is then exhausted and it continues as a free-fall particle.

a. How high above the Earth is the rocket when the fuel is exhausted?
b. What maximum altitude does the rocket reach? Neglect the effects of air friction.

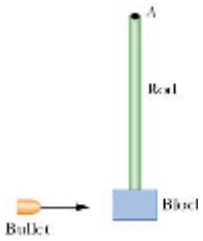
2. A block of mass $m = 0.05$ kg is attached to a cord of length $L = 30$ cm that is attached to a nail at the center of a table by means of a loop in the cord. Someone has set the block in motion so that it is swinging around the nail along a circular path. The cord is stretched tight with tension 1.5 N when suddenly the cord breaks. The block slides across the table, covering a total horizontal distance of 1.70 m, and then falls off the edge of the table. The table top is 75 cm above the floor and the coefficient of kinetic friction between the table top and the block is 0.15. How far (horizontally) from the table does the block strike the floor?

3. A lab uses two independent tests to determine the speed of a bullet fired from a new type of pistol:

a. In <u>test A</u>, the bullet (mass $m =$ 1.0 gram) is fired horizontally into a wooden block of mass $M = 0.50$ kg initially at rest on a horizontal surface. The known coefficient of kinetic friction between the block and surface is 0.20 and from the distance d the block travels after the bullet comes to rest in the block, the lab determines an initial speed of 1.35×10^3 m/s for the bullet before it enters the block. What value did they measure for d?



b. In <u>test B</u>, an identical bullet (mass $m =$ 1.0 gram) is fired into an identical wooden block mass ($M =$ 0.50 kg). This time, however, the block is not at rest on a surface but is attached to the end of a nonuniform rod (length $L = 0.60$ m) that has mass $M_{rod} =$ 0.50 kg and rotational inertia $I =$ 0.060 kg·m^2 (about A in the diagram at right). By observing the height to which the block rises after the bullet is embedded in the block, the lab works backward to determine the angular speed of the block-rod-bullet system about A just after the impact and from this, a linear speed of 1.35×10^3 m/s for the bullet right before impact. What was the <u>linear</u> speed of the block right <u>after</u> impact?



4. A block is on a piston that is moving vertically with simple harmonic motion. If the piston has an amplitude of 6.2 cm, for what frequency or frequencies will the block and piston be in contact continuously?

Useful Facts:

Quadratic Eq: $ax^2 + bx + c = 0$ $\quad x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$v = v_o + at$

$x = x_o + v_o t + \frac{1}{2}at^2$

$v^2 = v_o^{\,2} + 2a(x - x_o)$

$x - x_o = \frac{1}{2}(v_o + v)t$

$R = \dfrac{v_o^{\,2}}{g}\sin 2\theta_o$ (Range Eq.)

$\vec{v}_{PA} = \vec{v}_{PB} + \vec{v}_{BA}$ (Relative Motion)

$a_R = \dfrac{v^2}{r}$ $\quad T = \dfrac{1}{f}$ $\quad v = \dfrac{2\pi r}{T}$ (Circular Motion)

$\sum \vec{F} = m\vec{a}$ (Law of Motion)

$f_k = \mu_k F_N$ (kinetic friction) $f_{s,\max} = \mu_s F_N$ (static friction)

$W = \vec{F} \cdot \vec{d}$ (Work - constant force) $\quad W = \int_{x_i}^{x_f} F(x)dx$ (variable force; 1D)

$W_{\text{net}} = \Delta K$ $\quad K = \frac{1}{2}mv^2$ (Work-Energy Principle)

$E = K + U$ = constant (Conservation of Mechanical Energy)

$U = mgy$ or $U = -\dfrac{GMm}{r}$ (gravity) $\quad U = \frac{1}{2}kx^2$ (spring force; $F = -kx$)

$P = \dfrac{dW}{dt} = \vec{F} \cdot \vec{v}$ (Power) $\quad M\vec{r}_{com} = \sum_{i=1}^{N} m_i \vec{r}_i$ (Center of Mass)

$\vec{p} = m\vec{v}$ $\quad \vec{F} = \dfrac{d\vec{p}}{dt}$ $\quad \vec{p}_{1i} + \vec{p}_{2i} = \vec{p}_{1f} + \vec{p}_{2f}$ (Any collision)

$$v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1i} + \frac{2m_2}{m_1 + m_2} v_{2i}$$

$$v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1i} + \frac{m_2 - m_1}{m_1 + m_2} v_{2i}$$

(Elastic Collisions)

$\vec{J} = \int_{t_i}^{t_f} \vec{F}(t)dt = \Delta\vec{p}$ (Impulse)

$\theta = \dfrac{s}{r}$ $\quad \omega = \dfrac{d\theta}{dt}$ $\quad \alpha = \dfrac{d\omega}{dt}$ (Angular variables)

$v = r\omega \qquad a_t = r\alpha \qquad a_R = \frac{v^2}{r} = \omega^2 r \qquad \vec{a} = \vec{a}_{\tan} + \vec{a}_R$ (Rigid Body Rotation)

$\omega = \omega_o + \alpha t \qquad \Delta\theta = \omega_o t + \frac{1}{2}\alpha t^2$

$\omega^2 = \omega_o^2 + 2\alpha\theta \qquad \Delta\theta = \frac{1}{2}(\omega + \omega_o)t$ (Constant α)

$v_{\text{com}} = \omega r$ (Rolling)

$\vec{\tau} = \vec{r} \times \vec{F} \qquad \tau = r_\perp F = rF_\perp = rF\sin\phi$ (Torque)

$\tau_{\text{net}} = I\alpha \qquad W = \int_{\theta_i}^{\theta_f} \tau d\theta \qquad P = \frac{dW}{dt} = \tau\omega$

$I = \sum mr^2$ (Moment of Inertia) $K_{\text{rot}} = \frac{1}{2}I\omega^2 \qquad I = I_{\text{com}} + Mh^2$

$I = (2/5)MR^2$ (solid sphere about any diameter)
$I = ½\, MR^2$ (solid cylinder about central axis)
$I = (1/12)\, ML^2$ (thin rod about axis through center perpendicular to length)

$\vec{\ell} = \vec{r} \times \vec{p}$ (Ang. Momentum of Particle) $\vec{L} = I\vec{\omega}$ (Ang. Momentum of Rigid Body)

$\vec{\tau}_{\text{net}} = \frac{d\vec{L}}{dt} \qquad I_o\omega_o = I\omega$ (Zero net torque)

$\sum \vec{F} = 0 \qquad \sum \vec{\tau} = 0$ (Conditions for static equilibrium)

$F = -kx$ (Spring Force) $f = \frac{1}{T}$ (Frequency/Period relationship)

$E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2 = \frac{1}{2}mv_o^2$ (Energy in Simple Harmonic Motion)

$x = A\cos(\omega t + \phi) \qquad v = -\omega A\sin(\omega t + \phi) \qquad a = -\omega^2 A\cos(\omega t + \phi)$

$T = 2\pi\sqrt{\frac{m}{k}} \qquad \omega = 2\pi f$ (Mass-spring) $f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$ (Simple Pendulum)

$F = \frac{GMm}{r^2} \qquad U = -\frac{GMm}{r} \qquad v_{\text{esc}} = \sqrt{\frac{2GM}{R}}$ (Universal Gravity)

$c = 3.00 \times 10^8$ m/s
$g = 9.81$ m/s^2 = 32.2 ft/s^2
$G = 6.67 \times 10^{-11}$ N · m^2/kg^2

$M_{\text{earth}} = 5.98 \times 10^{24}$ kg = mass of earth
$R_{\text{earth}} = 6.37 \times 10^6$ m = radius of earth

1 m = 100 cm = 1000 mm = 10^{-3} km
1 kg = 1000 grams